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(54) **METHOD AND APPARATUS FOR ENCODING TRANSPORT BLOCK**

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H04W 4/00 (2009.01)
H04L 1/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H04L 1/004*** (2013.01)

(58) **Field of Classification Search**
CPC H04W 28/04
See application file for complete search history.

(56) **References Cited**

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(57) **ABSTRACT**

A method and apparatus for encoding a transport block are provided. The method for encoding the transport block includes: determining, by a transmitter, a size of transport block; dividing, by the transmitter, the transport block into at least one code block based on the size of transport block; interleaving, by the transmitter, the at least one code block by an interleaver; and performing, by the transmitter, a turbo coding for the interleaved at least one code block, wherein the size of transport block is determined based on the number of the divided code blocks.

10 Claims, 14 Drawing Sheets

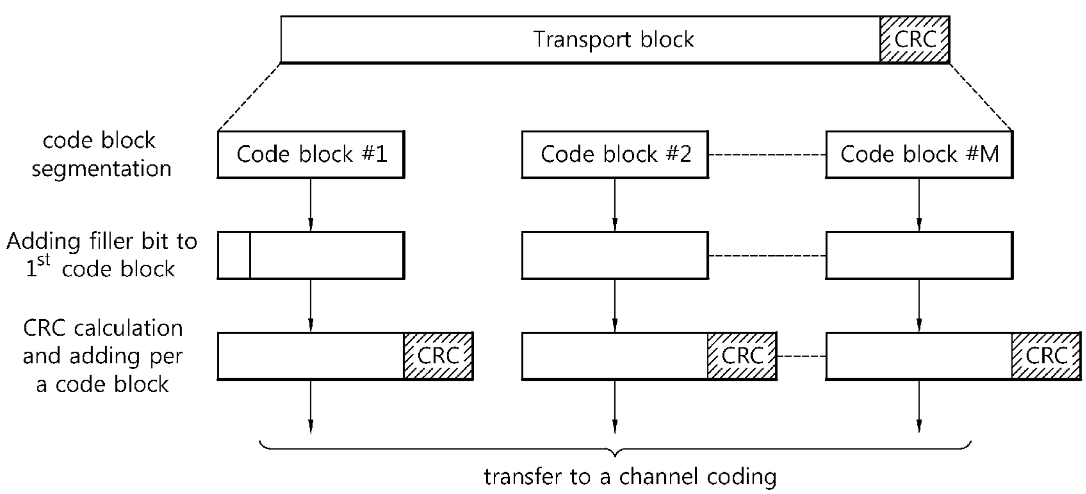


FIG. 1

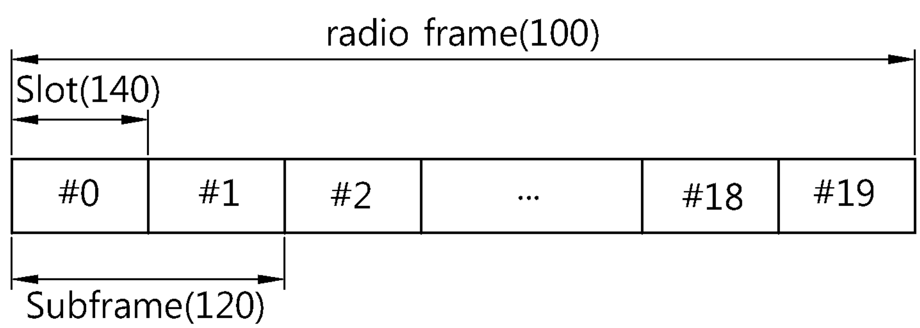


FIG. 2

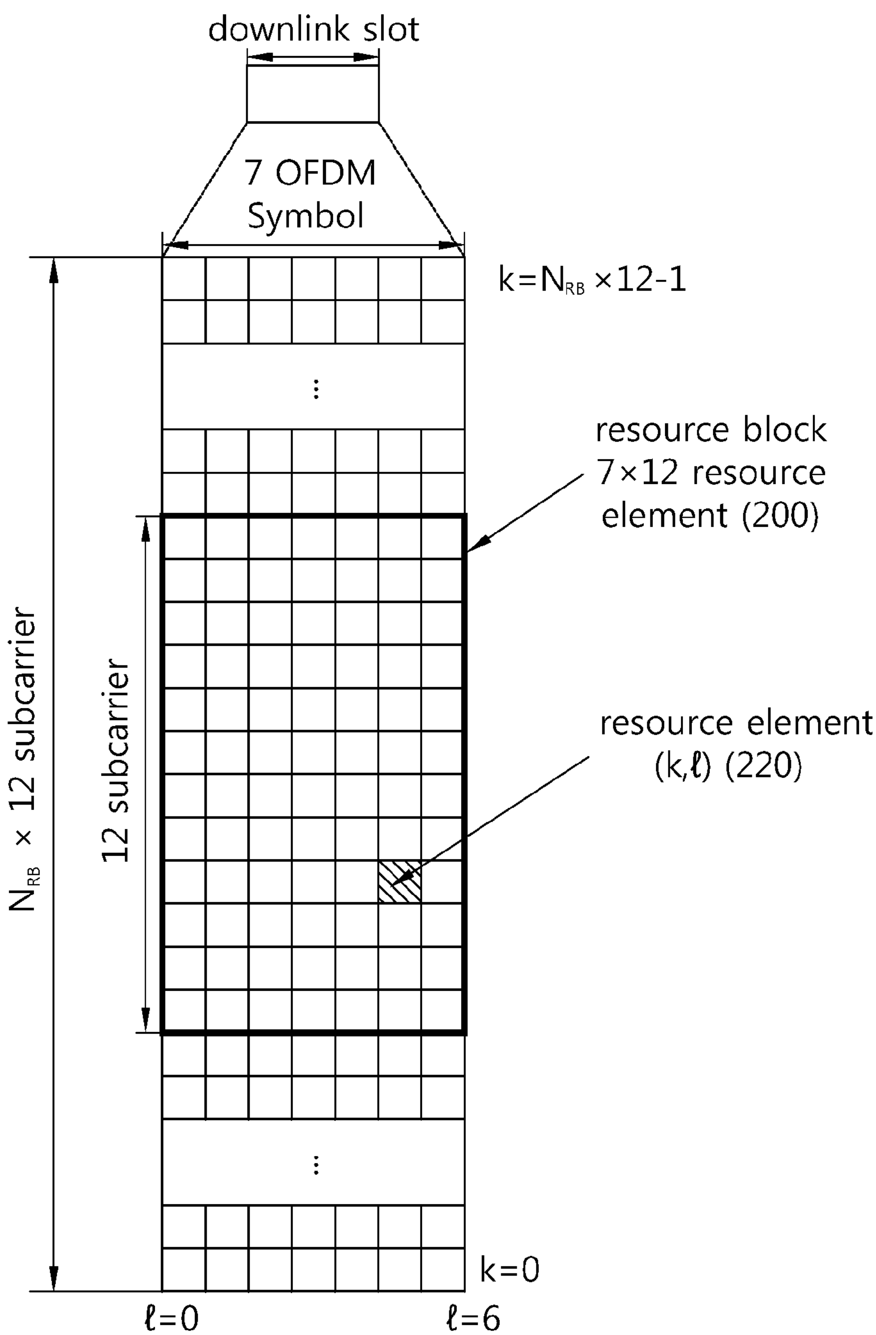

downlink slot
7 OFDM Symbol
k=N_RB ×12-1
resource block 7×12 resource element (200)
N_RB × 12 subcarrier
12 subcarrier
resource element (k,ℓ) (220)
k=0
ℓ=0
ℓ=6

FIG. 3

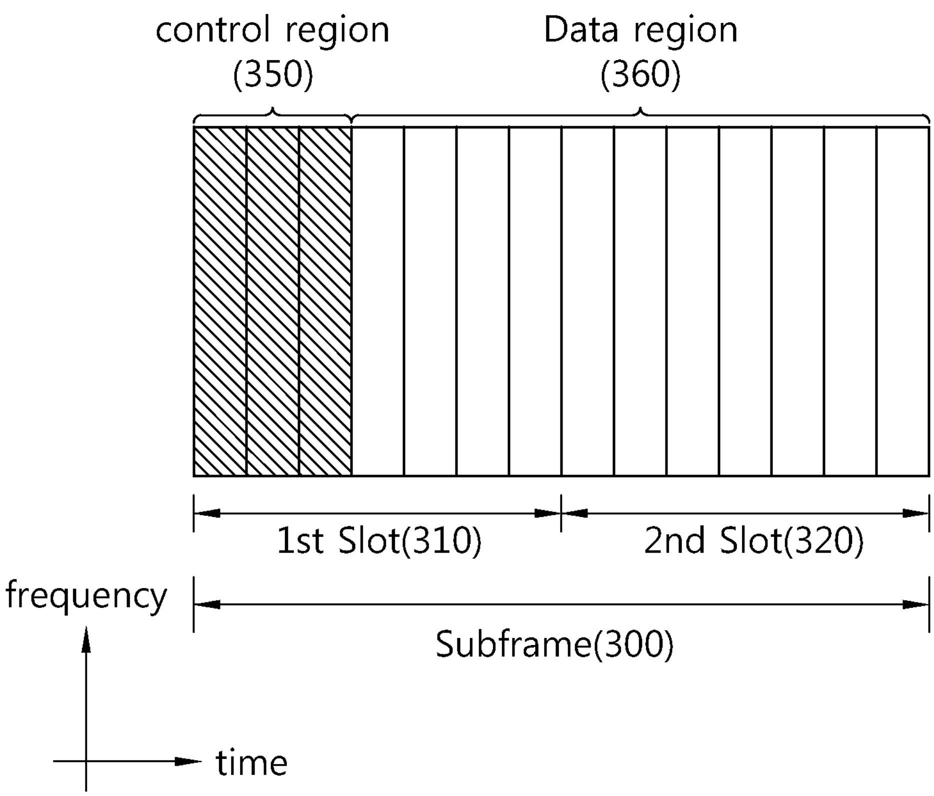

control region
(350)
Data region
(360)
1st Slot(310)
2nd Slot(320)
frequency
Subframe(300)
time

FIG. 4

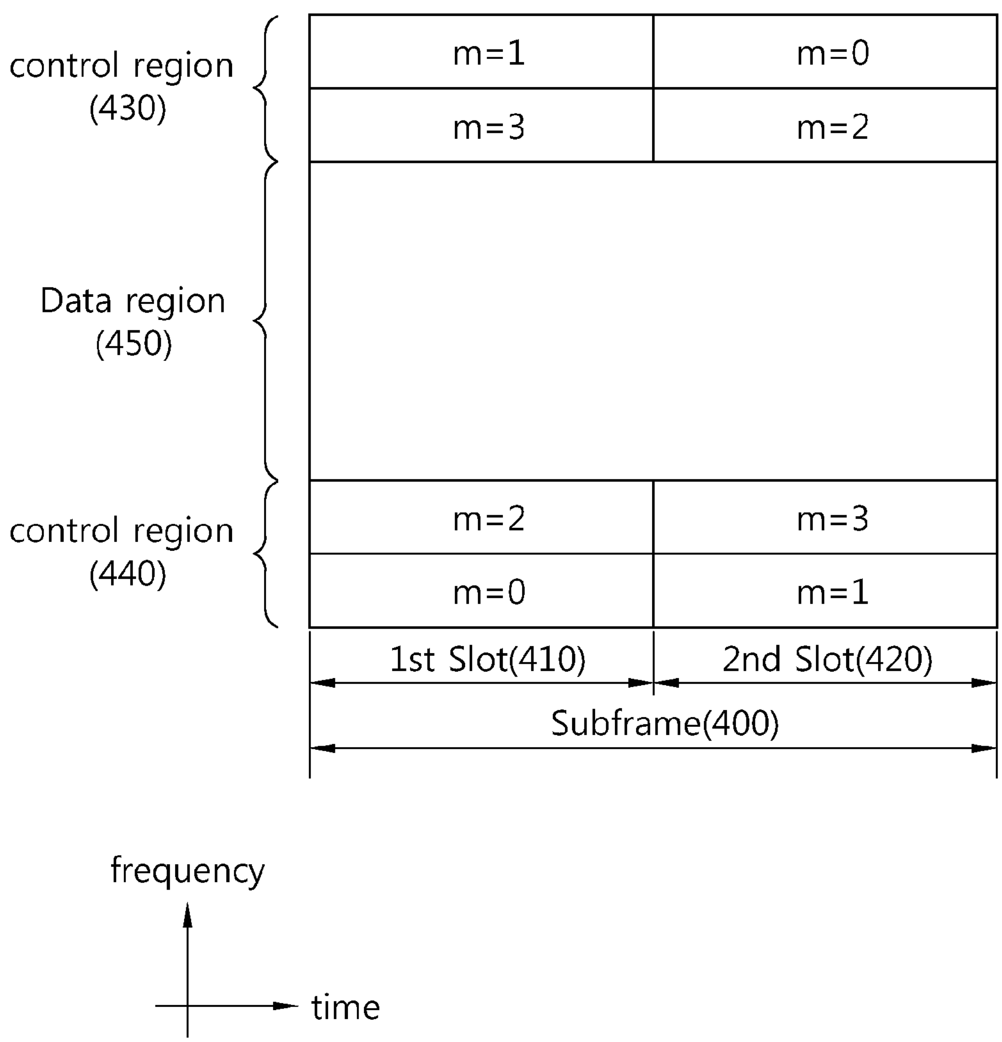

control region
(430)
m=1
m=0
m=3
m=2
Data region
(450)
control region
(440)
m=2
m=3
m=0
m=1
1st Slot(410)
2nd Slot(420)
Subframe(400)
frequency
time

FIG. 5

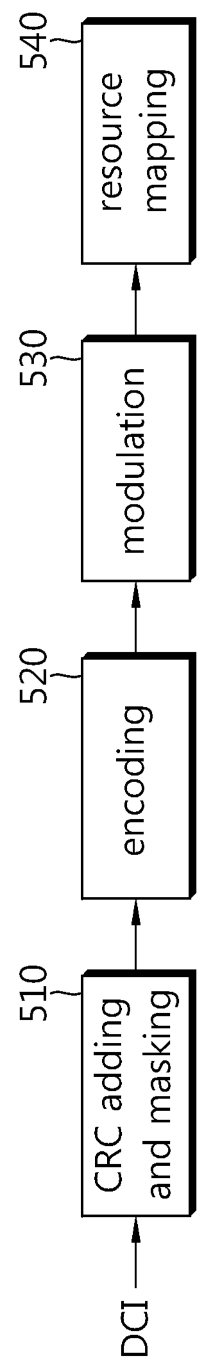

DCI
510
CRC adding and masking
520
encoding
530
modulation
540
resource mapping

FIG. 6

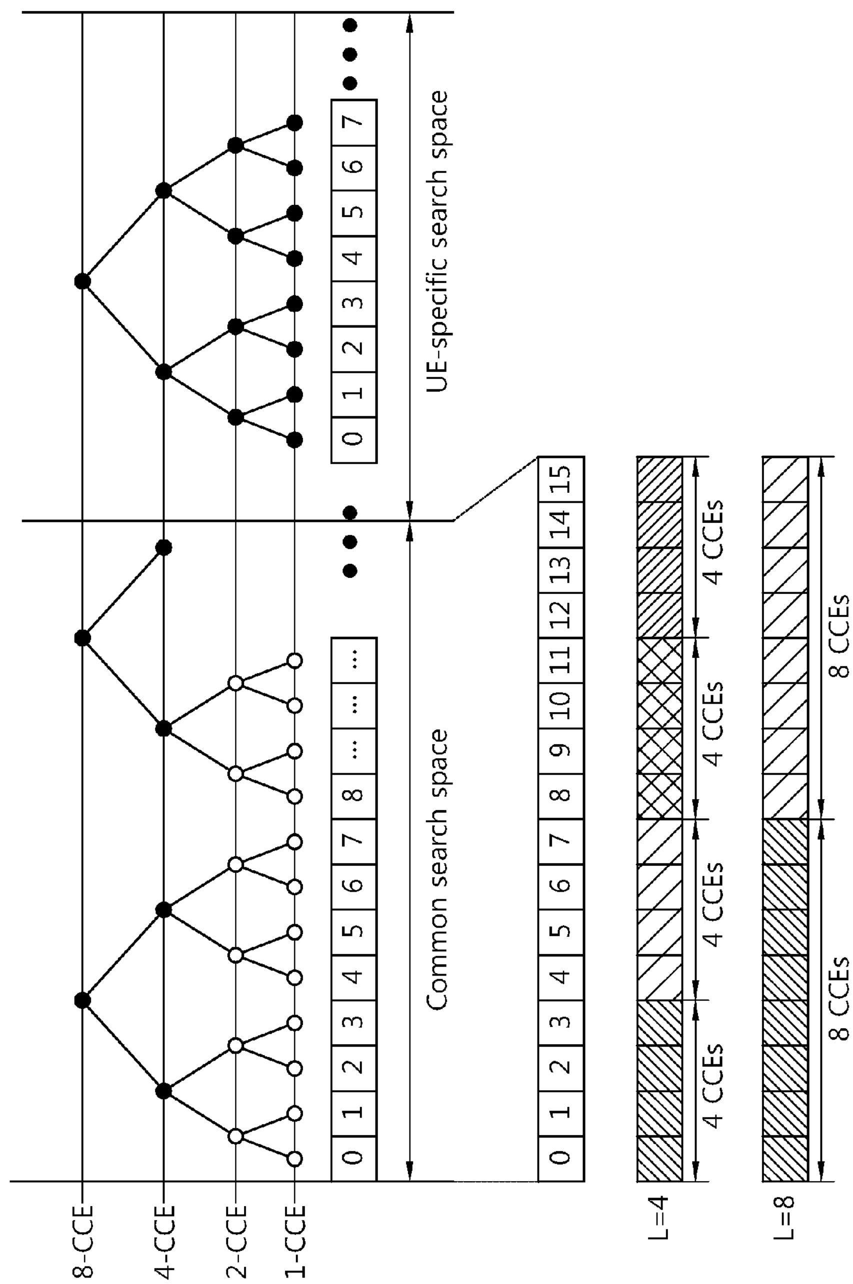

8-CCE
4-CCE
2-CCE
1-CCE
0 1 2 3 4 5 6 7 8 ... ...
0 1 2 3 4 5 6 7
Common search space
UE-specific search space
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
L=4
4 CCEs
4 CCEs
4 CCEs
4 CCEs
L=8
8 CCEs
8 CCEs

FIG. 7

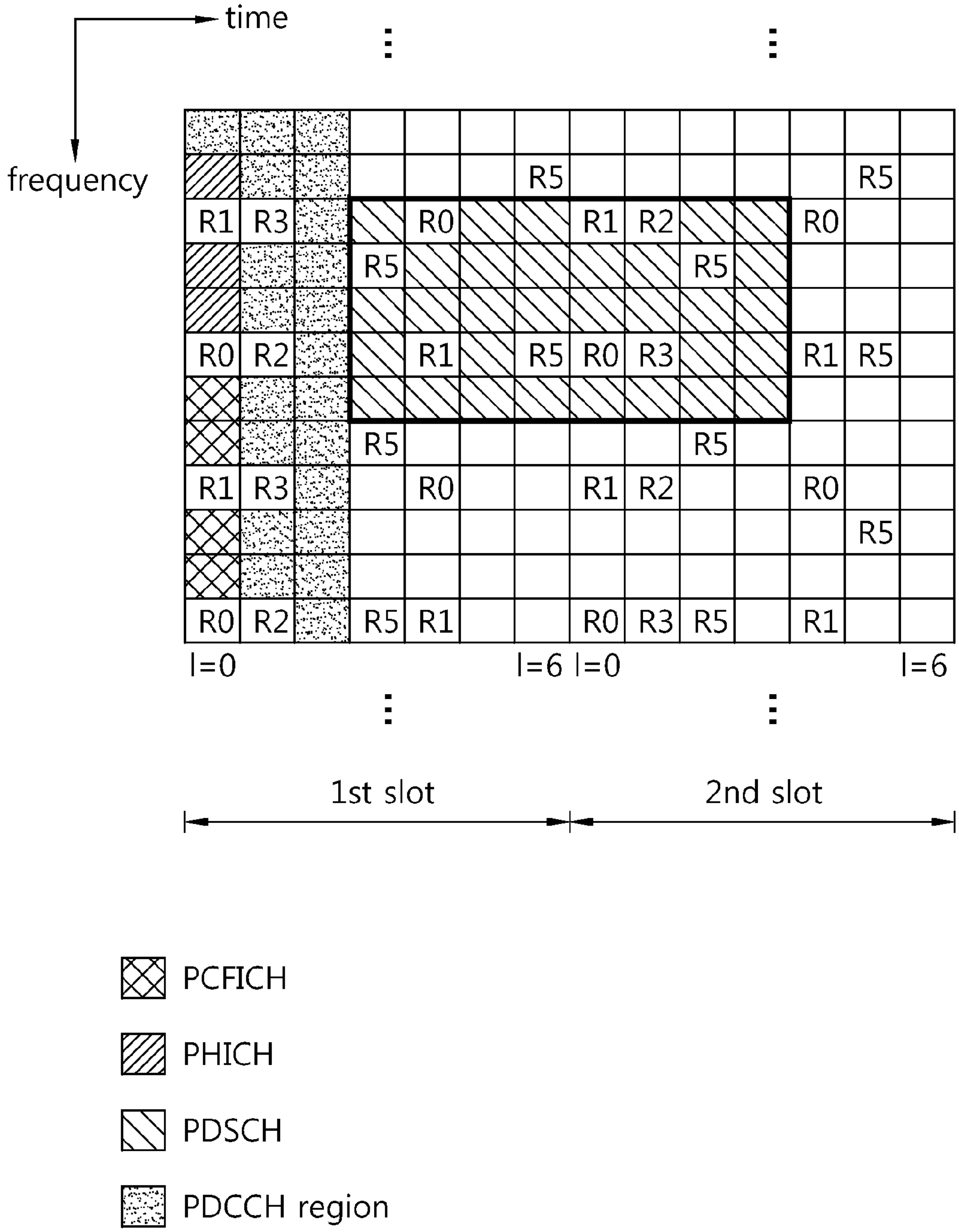

time
frequency
R5
R5
R1
R3
R0
R1
R2
R0
R5
R5
R0
R2
R1
R5
R0
R3
R1
R5
R5
R5
R1
R3
R0
R1
R2
R0
R5
R0
R2
R5
R1
R0
R3
R5
R1
l=0
l=6
l=0
l=6
1st slot
2nd slot
PCFICH
PHICH
PDSCH
PDCCH region

FIG. 8

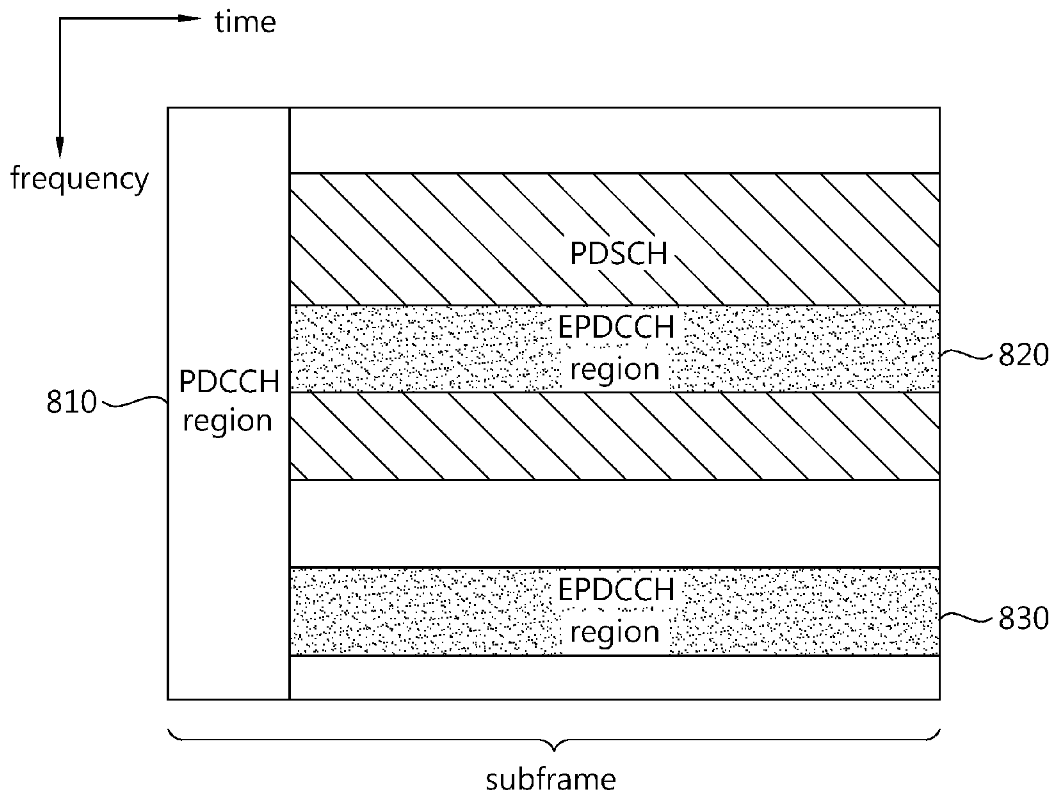

time
frequency
PDSCH
EPDCCH region
820
810
PDCCH region
EPDCCH region
830
subframe

FIG. 9

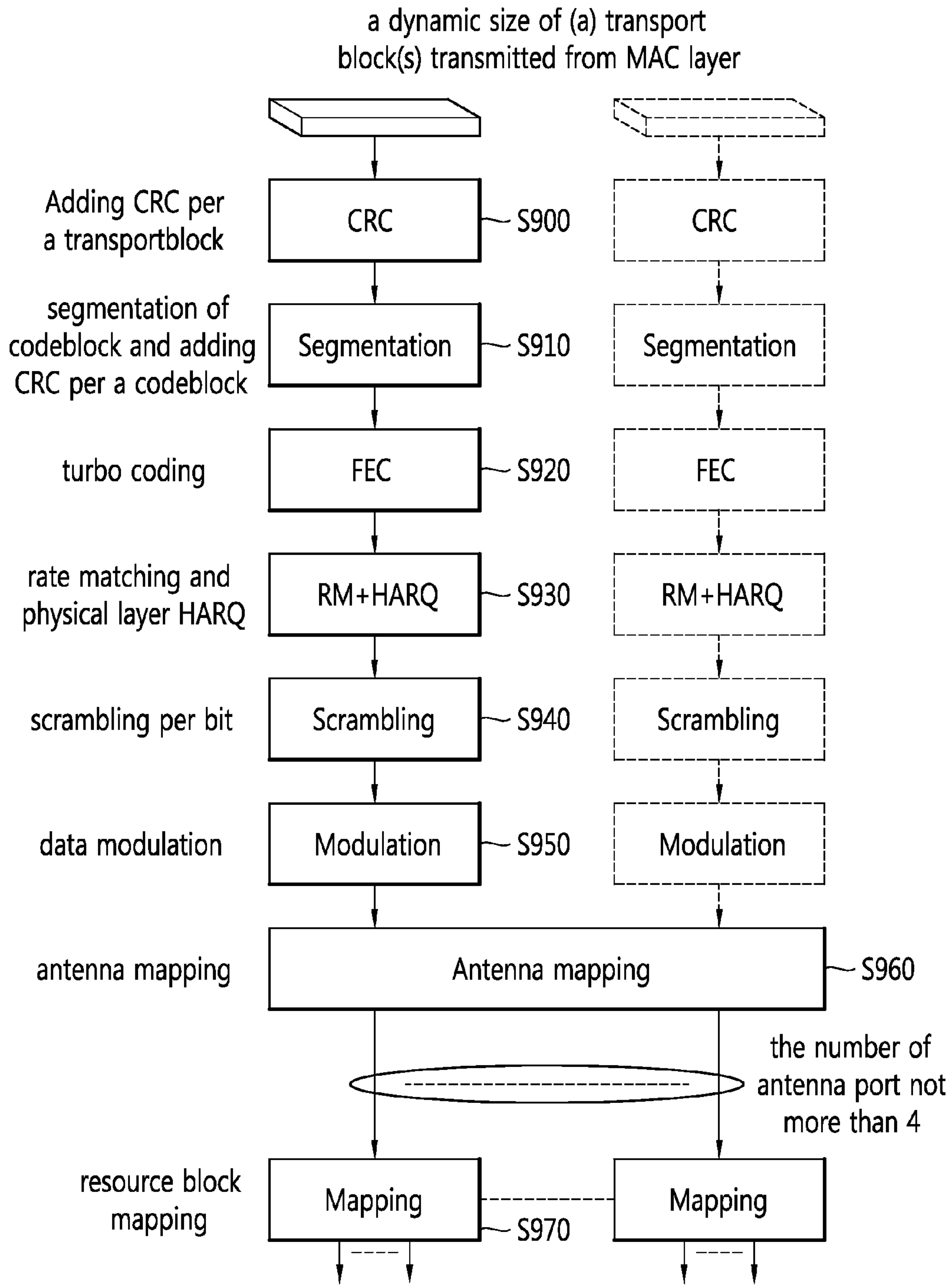

a dynamic size of (a) transport block(s) transmitted from MAC layer
Adding CRC per a transportblock
CRC
S900
CRC
segmentation of codeblock and adding CRC per a codeblock
Segmentation
S910
Segmentation
turbo coding
FEC
S920
FEC
rate matching and physical layer HARQ
RM+HARQ
S930
RM+HARQ
scrambling per bit
Scrambling
S940
Scrambling
data modulation
Modulation
S950
Modulation
antenna mapping
Antenna mapping
S960
the number of antenna port not more than 4
resource block mapping
Mapping
S970
Mapping

FIG. 10

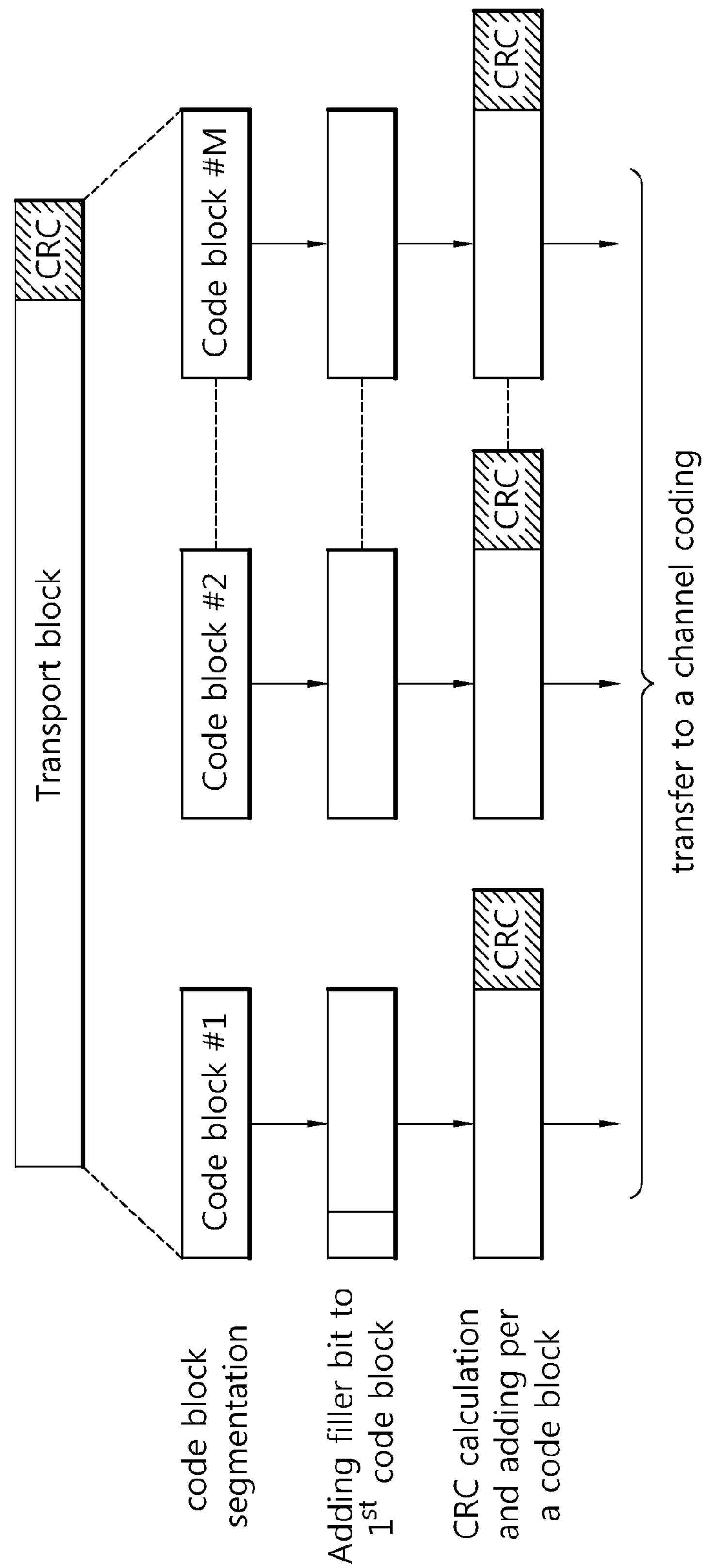

Transport block
CRC
code block segmentation
Code block #1
Code block #2
Code block #M
Adding filler bit to 1st code block
CRC calculation and adding per a code block
CRC
CRC
CRC
transfer to a channel coding

FIG. 11

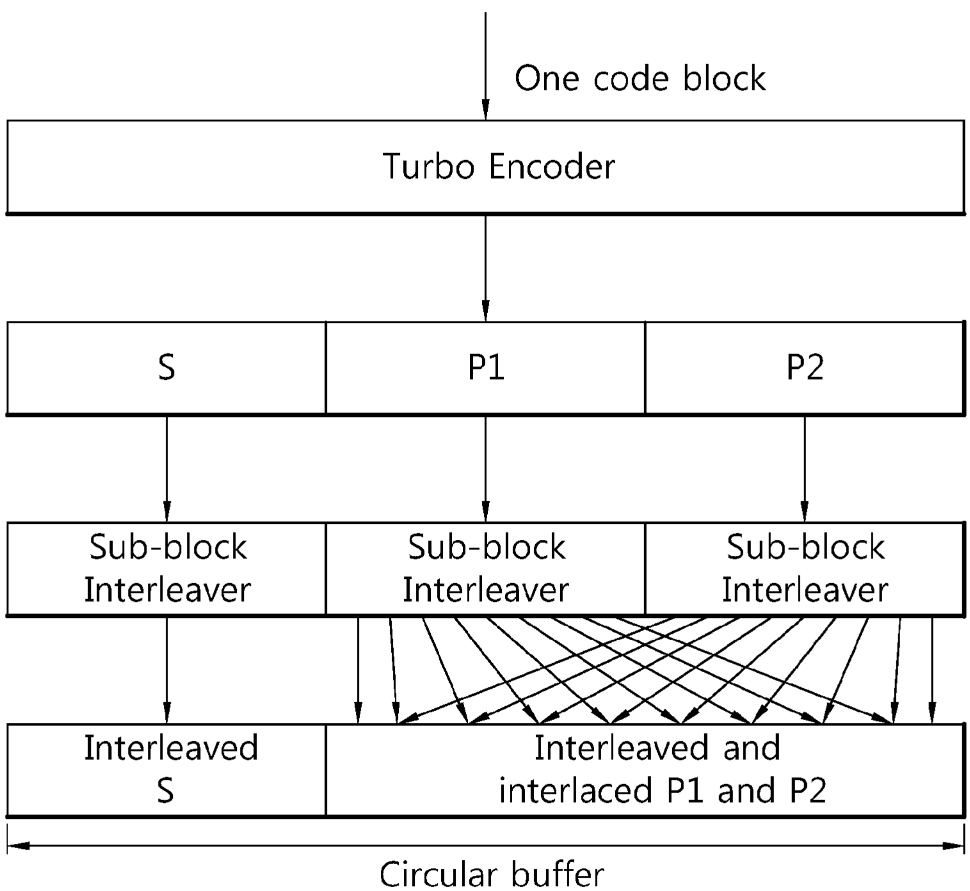

One code block
Turbo Encoder
S
P1
P2
Sub-block Interleaver
Sub-block Interleaver
Sub-block Interleaver
Interleaved S
Interleaved and interlaced P1 and P2
Circular buffer

FIG. 12

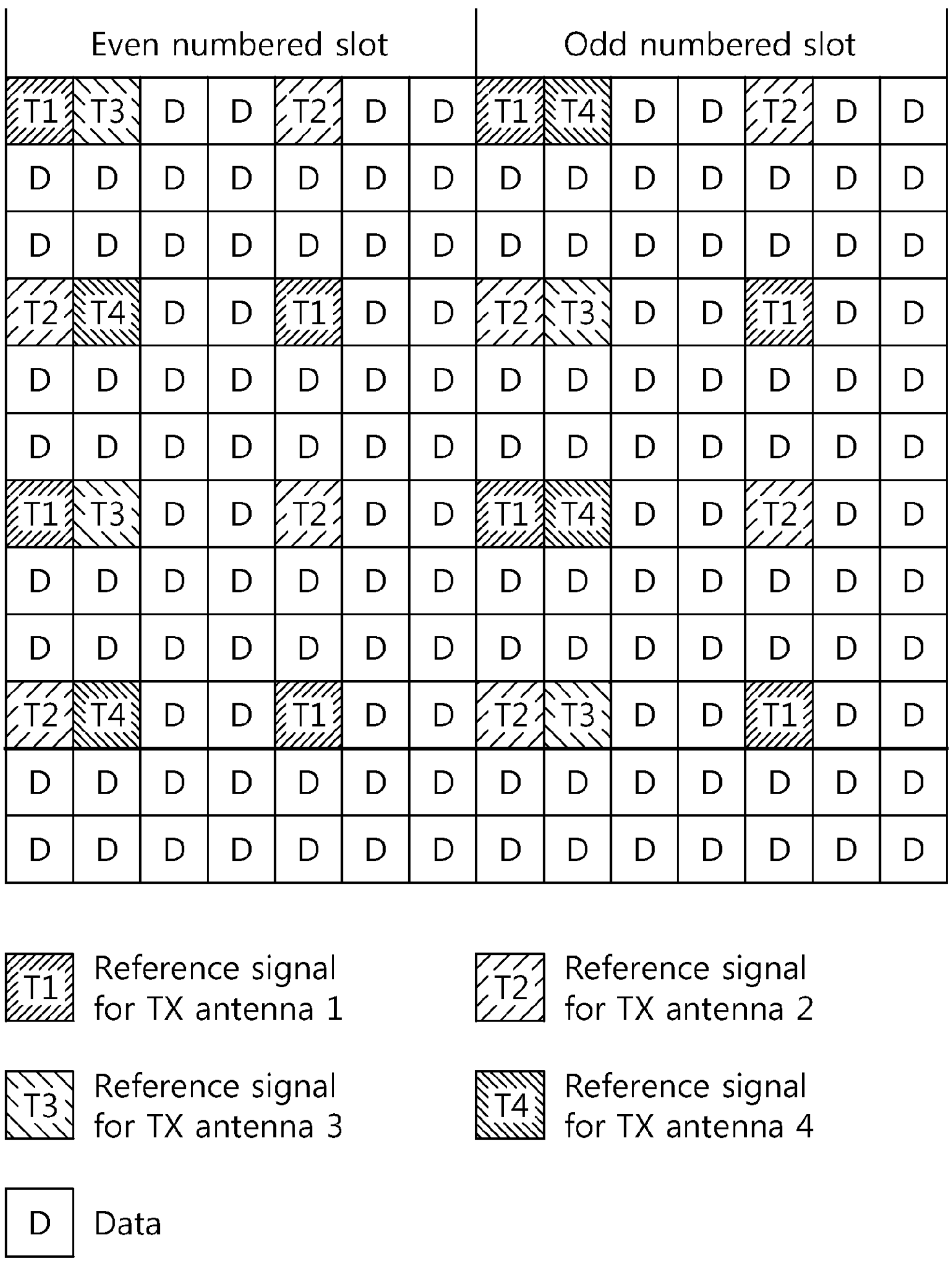

Even numbered slot
Odd numbered slot
T1 Reference signal for TX antenna 1
T2 Reference signal for TX antenna 2
T3 Reference signal for TX antenna 3
T4 Reference signal for TX antenna 4
D Data

FIG. 13

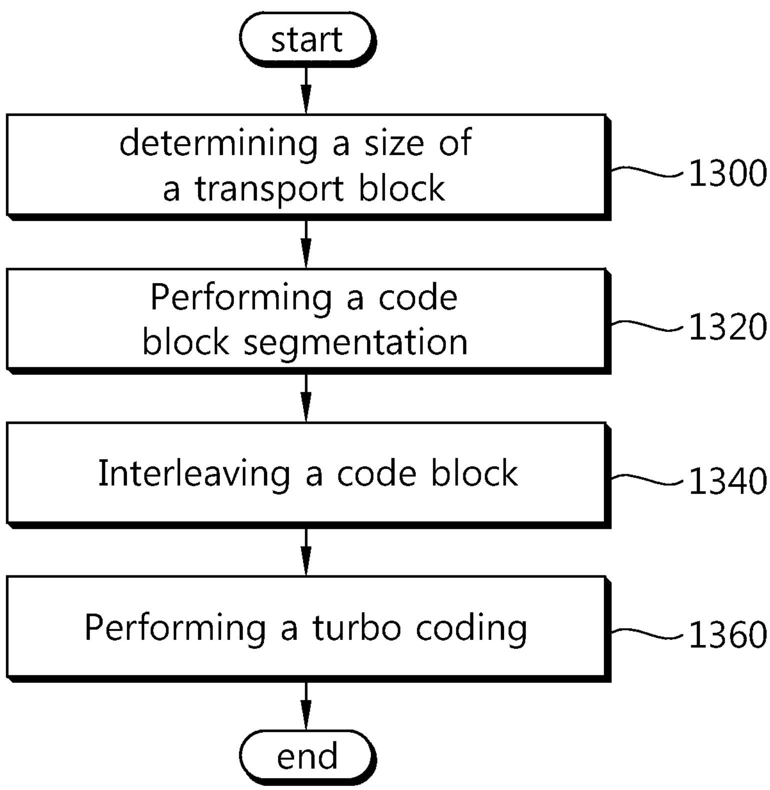
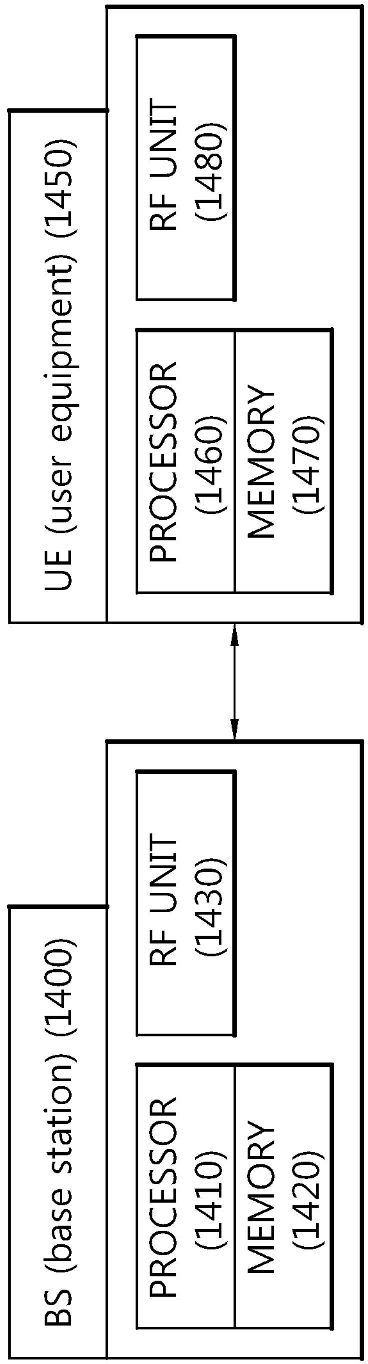

start
determining a size of a transport block
1300
Performing a code block segmentation
1320
Interleaving a code block
1340
Performing a turbo coding
1360
end

FIG. 14


UE (user equipment) (1450)
PROCESSOR (1460)
MEMORY (1470)
RF UNIT (1480)
BS (base station) (1400)
PROCESSOR (1410)
MEMORY (1420)
RF UNIT (1430)

METHOD AND APPARATUS FOR ENCODING TRANSPORT BLOCK

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of priority of U.S. Provisional applications No. 61/732,893 filed on Dec. 3, 2012, all of which is incorporated by reference in their entirety herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to wireless communications, and more particularly, to a method and apparatus for encoding a transport block.

2. Related Art

Extensive researches are underway in LTE (long term evolution) release 12 to improve performance in terms of capacity, coverage, coordination between cells, and costs. There is an ongoing discussion to introduce various techniques in the LTE release 12 in a technical aspect to improve performance, such as small cell enhancement, macro cell enhancement, new carrier type, machine type communication, etc.

The LTE release 12 aims at improving the capacity and coverage, which may be achieved by using small cell enhancement based on inter-site carrier aggregation, LTE-WLAN (wireless local area network) integration, and micro cell enhancement. Assuming a case where a cell is decreased in size, inter-cell movement of a terminal occurs frequently, which may result in an increase in an amount of traffic signaled when the terminal moves. To solve such a problem, a method of optimizing a small cell by decreasing signaling transmitted from an RAN (radio access network) to a core network on the basis of the small cell enhancement is under discussion in the LTE release 12.

In addition, an NCT (new carrier type) discussed in the LTE release 12 is a frame type which is newly defined differently from a legacy frame structure. Although the NCT can be a carrier type optimized for a small cell, it can also be applied to a macro cell. For example, in the NCT, an overhead generated by transmitting a reference signal such as a CRS (cell-specific reference signal) can be decreased, and a downlink control channel can be demodulated on the basis of a DM-RS (demodulation reference signal). By newly defining the NCT, energy of a base station can be saved, and an interference generated in a HetNet (heterogeneous network) can be decreased. In addition, the use of the NCT can decrease a reference signal overhead generated in data transmission using a plurality of downlink antennas. More specifically, although the legacy frame structure (e.g., a CP (cyclic prefix) length, a subframe structure, a duplexing mode, etc.) is maintained in the NCT, a control channel and/or a reference signal can be newly defined.

SUMMARY OF THE INVENTION

The present invention provides a method of encoding a transport block.

The present invention also provides an apparatus for encoding a transport block.

According to one aspect of the present invention, a method for encoding a transport block in a wireless communication system is provided. The method includes: determining, by a transmitter, a size of transport block; dividing, by the transmitter, the transport block into at least one code block based on the size of transport block; interleaving, by the transmitter, the at least one code block by an interleaver; and performing, by the transmitter, a turbo coding for the interleaved at least one code block, wherein the size of transport block is determined based on the number of the divided code blocks.

According to another aspect of the present invention, a wireless apparatus configured for encoding a transport block in a wireless communication system is provided. The wireless apparatus includes: a transceiver configured to receive radio signals; and a processor operatively coupled with the transceiver and configured to: determine a size of transport block; divide the transport block into at least one code block based on the size of transport block; interleave the at least one code block by an interleaver; and perform a turbo coding for the interleaved at least one code block, wherein the size of transport block is determined based on a number of the divided code blocks.

Data transmission and reception performance can be improved by decreasing the number of dummy bits when coding a transport block.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a radio frame structure in LTE (long term evolution).

FIG. **2** shows an example of a resource grid for one downlink slot.

FIG. **3** shows a structure of a downlink subframe.

FIG. **4** shows a structure of an uplink subframe.

FIG. **5** is a block diagram showing a method of generating PDCCH (physical downlink control channel) data.

FIG. **6** shows an example of monitoring a PDCCH.

FIG. **7** shows a downlink subframe to which a reference signal and a control channel are allocated in 3GPP (3rd generation partnership project) LTE.

FIG. **8** is an example of a subframe having an EPDCCH (enhanced PDCCH).

FIG. **9** shows the concept of a method of processing a downlink transport channel according to an embodiment of the present invention.

FIG. **10** shows the concept of a method of performing code block segmentation.

FIG. **11** shows the concept of a method of performing rate matching.

FIG. **12** shows the concept of a resource block pair according to an embodiment of the present invention.

FIG. **13** is a flowchart showing a method of performing turbo coding for a transport block according to an embodiment of the present invention.

FIG. **14** is a block diagram of a wireless communication system according to an embodiment of the present invention.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

A wireless device may be fixed or mobile, and may be referred to as another terminology, such as a UE (user equipment), an MS (mobile station), an MT (mobile terminal), a UT (user terminal), an SS (subscriber station), a PDA (personal digital assistant), a wireless modem, a handheld device, a terminal, a wireless terminal, etc. The wireless device may also be a device supporting only data communication such as an MTC (machine-type communication) device.

A BS (base station) is generally a fixed station that communicates with the wireless device, and may be referred to as another terminology, such as an eNB (evolved-NodeB), a BTS (base transceiver system), an access point, etc.

Operations of a UE and/or a BS in 3GPP (3rd generation partnership project) LTE (long term evolution) or 3GPP LTE-A defined based on each of releases of 3GPP TS (technical specification) will be described hereinafter. In addition, the present invention may also apply to various wireless communication networks other than the 3GPP LTE/3GPP LTE-A. In the following description, LTE and/or LTE-A are collectively referred to as LTE.

FIG. **1** shows a radio frame structure in LTE.

In 3GPP LTE, a structure of a radio frame **100** is disclosed in the section 5 of 3GPP TS 36.211 V8.2.0 (2008-03) "Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation (Release 8)".

Referring to FIG. **1**, the radio frame **100** consists of 10 subframes **120**. One subframe **120** consists of two slots **140**. The radio frame **100** may be indexed based on the slots **140** indexed from a slot #0 to a slot #19, or may be indexed based on the subframes **120** indexed from a subframe #0 to a subframe #9. For example, the subframe #0 may include the slot #0 and the slot #1.

A time required to transmit one subframe **120** is defined as a TTI (transmission time interval). The TTI may be a scheduling unit for data transmission. For example, a length of one radio frame **100** may be 1 millisecond (ms), a length of one subframe **120** may be 1 ms, and a length of one slot **140** may be 0.5 ms.

One slot **140** includes a plurality of OFDM (orthogonal frequency division multiplexing) symbols in a time domain, and includes a plurality of subcarriers in a frequency domain. In LTE, a BS uses OFDMA as an access scheme in a downlink channel. The OFDM symbol is for representing one symbol period, and may be referred to as other terms according to a multiple access scheme. For example, an SC-FDMA (single carrier-frequency division multiple access) may be used as the multiple access scheme in an uplink channel in which data is transmitted from a UE to a BS. A symbol duration in which data is transmitted through the uplink channel may be called an SC-FDMA symbol.

The structure of the radio frame **100** described in FIG. **1** is one embodiment for a frame structure. Therefore, the number of subframes **120** included in the radio frame **100**, the number of slots **140** included in the subframe **120**, or the number of OFDM symbols included in the slot **140** may be changed variously to define a new radio frame format.

In the structure of the radio frame, the number of symbols included in one slot may vary depending on which CP (cyclic prefix) is used. For example, if the radio frame uses a normal CP, one slot may include 7 OFDM symbols. If the radio frame uses an extended CP, one slot may include 6 OFDM symbols.

As a duplexing scheme, a wireless communication system may use an FDD (frequency division duplex) scheme, a TDD (time division duplex) scheme, etc. In the FDD scheme, uplink transmission and downlink transmission may be performed based on different frequency bands. In the TDD scheme, uplink transmission and downlink transmission may be performed by using a time-based division scheme based on the same frequency band. Channel responses of the TDD scheme may have a reciprocal property since the same frequency band is used. That is, in the TDD scheme, a downlink channel response and an uplink channel response may be almost identical in a given frequency domain. Therefore, a TDD-based wireless communication system may acquire channel state information of a downlink channel from channel state information of an uplink channel. In the TDD system, a full frequency band is time-divided into uplink transmission and downlink transmission, and thus downlink transmission performed by the BS and uplink transmission performed by the UE may be performed simultaneously.

FIG. **2** shows an example of a resource grid for one downlink slot.

The downlink slot includes a plurality of OFDM symbols in a time domain, and includes NRB resource blocks in a frequency domain. The number NRB of resource blocks included in the downlink slot may be determined according to a downlink transmission bandwidth configured in a cell. For example, in the LTE system, NRB may be any one value in the range of 60 to 110 according to a transmission bandwidth in use. One resource block **200** may include a plurality of subcarriers in the frequency band. A structure of an uplink slot may be the same as the aforementioned structure of the downlink slot.

Each element on the resource grid is referred to as a resource element **220**. The resource element **220** on the resource grid may be identified by an index pair (k,l). Herein, k(k=0, . . . , NRB×12−1) denotes a subcarrier index in the frequency domain, and l(l=0, . . . , 6) denotes an OFDM symbol index in the time domain.

Herein, one resource block **200** may include 7×12 resource elements **220** consisting of 7 OFDM symbols in the time domain and 12 subcarriers in the frequency domain. Such a size is one example, and thus the number of OFDM symbols and the number of subcarriers constituting one resource block **200** may change. A resource block pair indicates a resource unit including two resource blocks.

The number of OFDM symbols included in one slot may have a different value depending on a CP as described above. In addition, the number of resource blocks included in one slot may vary depending on a size of a full frequency bandwidth.

FIG. **3** shows a structure of a downlink subframe.

A downlink subframe **300** may be divided into two slots **310** and **320** according to a time. Each of the slots **310** and **320** includes 7 OFDM symbols in a normal CP case. A resource region corresponding to first three OFDM symbols (i.e., in case of 1.4 MHz bandwidth, up to 4 OFDM symbols) included in the first slot **310** of the subframe **300** may be used as a control region **350** to which control channels are allocated. The remaining OFDM symbols may be used as a data region **360** to which a traffic channel such as a PDSCH (physical downlink shared channel) is allocated.

A PDCCH (physical downlink control channel) may be a control channel for transmitting a resource allocation and transmission format of a DL-SCH (downlink-shared channel), resource allocation information of a UL-SCH (uplink shared channel), paging information on a PCH, system information on a DL-SCH, a resource allocation of a higher layer control message such as a random access response transmitted through a PDSCH, a transmission power control command for individual UEs included in any UE group, activation of a VoIP (voice over internet protocol), etc. A plurality of units of transmitting PDCCH data may be defined within the control region **350**. The UE may acquire control data by monitoring the plurality of units of transmitting the PDCCH data. For example, the PDCCH data may be transmitted to the UE on the basis of an aggregation of one or several consecutive CCEs (control channel elements). The CCE may be one unit of transmitting the PDCCH data. The CCE may include a plurality of resource element groups. The resource element group is a resource unit including four available resource elements.

A BS determines a PDCCH format according to DCI (downlink control information) to be transmitted to a UE, and attaches a CRC (cyclic redundancy check) to control information. The CRC is masked with a unique identifier (referred to as an RNTI (radio network temporary identifier)) according to an owner or usage of the PDCCH. If the PDCCH is for a specific UE, a unique identifier (e.g., C-RNTI (cell-RNTI)) of the UE may be masked to the CRC. Alternatively, if the PDCCH is for a paging message, a paging indicator identifier (e.g., P-RNTI (paging-RNTI)) may be masked to the CRC. If the PDCCH is for an SIB (system information block), a system information identifier and an SI-RNTI (system information-RNTI) may be masked to the CRC. To indicate a random access response that is a response for transmission of a random access preamble of the UE, an RA-RNTI (random access-RNTI) may be masked to the CRC.

FIG. **4** shows a structure of an uplink subframe.

The uplink subframe may be divided into control regions **430** and **440** and a data region **450**. A PUCCH (physical uplink control channel) for carrying uplink control information is allocated to the control regions **430** and **440**. A PUSCH (physical uplink shared channel) for carrying data is allocated to the data region **450**. When indicated by a higher layer, a UE may support simultaneous transmission of the PUSCH and the PUCCH.

The PUCCH for one UE is allocated in an RB (resource block) pair in a subframe. RBs belonging to the RB pair occupy different subcarriers in each of a 1st slot **410** and a 2nd slot **420**. A frequency occupied by the RBs belonging to the RB pair changes at a slot boundary. This is called that the RB pair allocated to the PUCCH is frequency-hopped at the slot boundary. Since the UE transmits the UCI on a time basis through different subcarriers, a frequency diversity gain can be obtained. m is a location index indicating a logical frequency-domain location of the RB pair allocated to the PUCCH in the subframe.

Examples of uplink control information transmitted on a PUCCH may include HARQ (hybrid automatic repeat request) ACK (acknowledgement)/NACK (non-acknowledgement), CQI (channel quality indicator) indicating a downlink channel state, SR (scheduling request) which is an uplink radio resource allocation request, etc.

The PUSCH is a channel mapped to a UL-SCH (uplink shared channel) which is a transport channel. Uplink data transmitted through the PUSCH may be a transport block which is a data block for the UL-SCH transmitted during a TTI. The transport block may include user information. In addition, the uplink data may be multiplexed data. The multiplexed data may be obtained by multiplexing control information and a transport block for the UL-SCH. Examples of the control information multiplexed to the data may include CQI, PMI (precoding matrix indicator), HARQ ACK/NACK, RI (rank indicator), etc. Alternatively, the uplink data may consist of only the control information.

FIG. **5** is a block diagram showing a method of generating PDCCH data.

In FIG. **5**, a method of generating PDCCH data is described in detail.

A UE performs blind decoding to detect a PDCCH. The blind decoding may be performed on the basis of an identifier masked to a CRC (cyclic redundancy check) of a received PDCCH (referred to as a candidate PDCCH). By checking an CRC error of the received PDCCH data, the UE may determine whether the PDCCH data is its own control data.

A BS determines a PDCCH format according to DCI (downlink control information) to be transmitted to the UE and thereafter attaches a CRC to the DCI, and masks a unique identifier (referred to as an RNTI (radio network temporary identifier)) to the CRC according to an owner or usage of the PDCCH (block **510**).

If the PDCCH is for a specific UE, the BS may mask a unique identifier (e.g., C-RNTI (cell-RNTI)) of the UE to the CRC. Alternatively, if the PDCCH is for a paging message, the BS may mask a paging indication identifier (e.g., P-RNTI (paging-RNTI)) to the CRC. If the PDCCH is for system information, the BS may mask a system information identifier (e.g., SI-RNTI (system information-RNTI)) to the CRC. In addition thereto, the BS may mask an RA-RNTI (random access-RNTI) to the CRC in order to indicate a random access response that is a response for transmission of a random access preamble of the UE, and may mask a TPC-RNTI to the CRC in order to indicate a TPC (transmit power control) command for a plurality of UEs.

A PDCCH masked with the C-RNTI may transmit control information for a specific UE (such information is called UE-specific control information), and a PDCCH masked with a different RNTI may transmit common control information received by all or a plurality of UEs in a cell. A plurality of DCI formats may be defined to transmit PDCCH data. This will be additionally described in detail.

The BS encodes the CRC-attached DCI to generate coded data (block **520**). Encoding includes channel encoding and rate matching.

The BS generates modulation symbols by performing modulation on the coded data (block **530**).

The BS maps the modulation symbols to physical REs (resource elements) (block **540**). The BS may map the modulation symbols to the respective REs.

As described above, a control region in a subframe includes a plurality of CCEs (control channel elements). The CCE is a logical allocation unit used to provide the PDCCH with a coding rate depending on a radio channel state, and corresponds to a plurality of REGs (resource element groups). The REG includes a plurality of resource elements. One REG includes 4 REs. One CCE includes 9 REGs. The number of CCEs used to configure one PDCCH may be selected from a set {1, 2, 4, 8}. Each element of the set {1, 2, 4, 8} is referred to as a CCE aggregation level.

The BS may determine the number of CCEs used in transmission of the PDCCH according to a channel state. For example, if a downlink channel state is good, the BS may use one CCE to transmit PDCCH data to the UE. On the contrary, if the downlink channel state is not good, the BS may use 8 CCEs to transmit PDCCH data to the UE.

A control channel consisting of one or more CCEs may perform interleaving in an REG unit, and may be mapped to a physical resource after performing cyclic shift based on a cell ID (identifier).

FIG. **6** shows an example of monitoring a PDCCH. The section 9 of 3GPP TS 36.213 V10.2.0 (2011-06) may be incorporated herein by reference.

A UE may perform blind decoding to detect the PDCCH. The blind decoding is a scheme in which a specific identifier is de-masked from a CRC of received PDCCH (referred to as candidate PDCCH) data and thereafter whether the PDCCH is its own control channel is determined by performing CRC error checking. The UE cannot know about a specific position in a control region in which its PDCCH data is transmitted and about a specific CCE aggregation level or DCI format used in transmission.

A plurality of PDCCHs may be transmitted in one subframe. The UE monitors the plurality of PDCCHs in every subframe. Herein, monitoring is an operation in which the UE attempts to perform blind decoding on the PDCCH.

The 3GPP LTE uses a search space to reduce an overload caused when the UE performs the blind decoding. The search space may also be called a monitoring set of a CCE for PDCCH searching. The UE may monitor the PDCCH on the basis of the search space.

The search space is classified into a common search space and a UE-specific search space. The common search space is a space for searching for a PDCCH having common control information and consists of 16 CCEs indexed with 0 to 15. The common search space supports a PDCCH having a CCE aggregation level of {4, 8}. However, a PDCCH (e.g., DCI formats 0, 1A) for carrying UE-specific information may also be transmitted in the common search space. The UE-specific search space supports a PDCCH having a CCE aggregation level of {1, 2, 4, 8}.

Table 1 shows the number of PDCCH candidates monitored by the UE.

TABLE 1

Search space $S_k^{(L)}$				
Type	Aggregation level L	Size [in CCEs]	Number of PDCCH candidates $M^{(L)}$	DCI format
UE-specific	1	6	6	0, 1, 1A, 1B, 1D, 2, 2A
	2	12	6	
	4	8	2	
	8	16	2	
Common	4	16	4	0, 1A, 1C, 3/3A
	8	16	2	

A size of search space is determined by Table 1 above, and a start point of the search space is defined differently in the common search space and the UE-specific search space. Although a start point of the common search space is fixed irrespective of a subframe, a start point of the UE-specific search space may vary in every subframe according to a UE identifier (e.g., C-RNTI), a CCE aggregation level, and/or a slot number in a radio frame. If the start point of the UE-specific search space exists in the common search space, the UE-specific search space and the common search space may overlap.

A set of PDCCH candidates monitored by the UE may be defined according to the search space. In the aggregation level 1, 2, 4, or 8, a search space $S_k^{(L)}$ is defined as the set of PDCCH candidates. In the search space $S_k^{(L)}$, a CCE corresponding to a PDCCH candidate m is given by Equation 1 below.

$$L\cdot\{(Y_k+m')\bmod\lfloor N_{CCE,k}/L\rfloor\}+i \qquad \text{<Equation 1>}$$

Herein, i=0, . . . , L−1. If the search space is a common search space, m'=m. If the search space is a UE-specific search space, $m'=m+M^{(L)}\cdot n_{CI}$ when a CIF (carrier indicator field) is set to the UE, where n_{CI} is a value of the set CIF. Further, m'=m when the CIF is not set to the UE. Herein, m=0, . . . , $M^{(L)}-1$, where $M^{(L)}$ is the number of PDCCH candidates for monitoring a given search space.

In a common search space, Y_k is set to 0 with respect to two aggregation levels L=4 and L=8. In a UE-specific search space of the aggregation level L, a variable Y_k is defined by Equation 2 below.

$$Y_k=(A\cdot Y_{k-1})\bmod D \qquad \text{<Equation 2>}$$

Herein, $Y_{-1}=n_{RNTI}\neq 0$, A=39827, D=65537, $k=\lfloor n_s/2\rfloor$. ns denotes a slot number in a radio frame.

When a wireless device monitors a PDCCH on the basis of a C-RNTI, a search space and a DCI format to be monitored are determined according to a transmission mode of a PDSCH. Table 2 below shows an example of PDCCH monitoring in which the C-RNTI is set.

TABLE 2

Transmission mode	DCI format	search space	Transmission mode of PDSCH based on PDCCH
Mode 1	DCI format 1A	common and UE specific	Single-antenna port, port 0
	DCI format 1	UE specific	Single-antenna port, port 0
Mode 2	DCI format 1A	common and UE specific	Transmit diversity
	DCI format 1	UE specific	Transmit diversity
Mode 3	DCI format 1A	common and UE specific	Transmit diversity
	DCI format 2A	UE specific	(CDD) Cyclic Delay Diversity or Transmit diversity
Mode 4	DCI format 1A	common and UE specific	Transmit diversity
	DCI format 2	UE-specific	Closed-loop spatial multiplexing
Mode 5	DCI format 1A	common and UE specific	Transmit diversity
	DCI format 1D	UE specific	MU-MIMO (Multi-User Multiple Input Multiple Output)
Mode 6	DCI format 1A	common and UE specific	Transmit diversity
	DCI format 1B	UE specific	Closed-loop spatial multiplexing
Mode 7	DCI format 1A	common and UE specific	If the number of PBCH transmission ports is 1, single antenna port, port 0, otherwise Transmit diversity
	DCI format 1	UE specific	Single antenna port, port 5
Mode 8	DCI format 1A	common and UE specific	If the number of PBCH transmission ports is 1, single antenna port, port 0, otherwise, Transmit diversity
	DCI format 2B	UE specific	Dual layer transmission (port 7 or 8), or a single antenna port, port 7 or 8

The usage of the DCI format is classified as shown in Table 3 below.

TABLE 3

DCI format	Contents
DCI format 0	It is used for PUSCH scheduling.
DCI format 1	It is used for scheduling of one PDSCH codeword.
DCI format 1A	It is used for compact scheduling and a random access process of one PDSCH codeword.
DCI format 1B	It is used in simple scheduling of one PDSCH codeword having precoding information.
DCI format 1C	It is used for very compact scheduling of one PDSCH codeword.
DCI format 1D	It is used for simple scheduling of one PDSCH codeword having precoding and power offset information.
DCI format 2	It is used for PDSCH scheduling of UEs configured to a closed-loop spatial multiplexing mode.
DCI format 2A	It is used for PDSCH scheduling of UEs configured to an open-loop spatial multiplexing mode.
DCI format 3	It is used for transmission of a TPC command of a PUCCH and a PUSCH having a 2-bit power adjustment.
DCI format 3A	It is used for transmission of a TPC command of a PUCCH and a PUSCH having a 1-bit power adjustment.

According to an RNTI masked to a CRC used when DCI is generated, a search space and a DCI format to be used may be set differently. Table 4 below shows a search space and a DCI format of a control channel used when SI-RNTI, P-RNTI, or RA-RNTI is masked to the CRC of the DCI.

TABLE 4

DCI format	search space	Transmission mode of PDSCH based on PDCCH
DCI format 1C	common	If the number of PBCH transmission ports is 1, single antenna port, port 0, otherwise Transmit diversity
DCI format 1A	common	If the number of PBCH transmission ports is 1, single antenna port, port 0, otherwise Transmit diversity

Table 5 below shows a DCI format and a search space of a control channel used when SPS-C-RNT is masked to the CRC of the DCI.

TABLE 5

Transmission mode	DCI format	search space	Transmission mode of PDSCH based on PDCCH
Mode 1	DCI format 1A	common and UE specific	Single antenna port, port 0
	DCI format 1	UE specific	Single antenna port, port 0
Mode 2	DCI format 1A	common and UE specific	Transmit diversity
	DCI format 1	UE specific	Transmit diversity
Mode 3	DCI format 1A	common and UE specific	Transmit diversity
	DCI format 2A	UE specific	Transmit diversity
Mode 4	DCI format 1A	common and UE specific	Transmit diversity
	DCI format 2	UE specific	Transmit diversity
Mode 5	DCI format 1A	common and UE specific	Transmit diversity
Mode 6	DCI format 1A	common and UE specific	Transmit diversity
Mode 7	DCI format 1A	common and UE specific	Single antenna port, port 5
	DCI format 1	UE specific	Single antenna port, port 5
Mode 8	DCI format 1A	common and UE specific	Single antenna port, port 7
	DCI format 2B	UE specific	Single antenna port, port 7 or 8
Mode 9	DCI format 1A	common and UE specific	Single antenna port, port 7
	DCI format 2C	UE specific	Single antenna port, port 7 or 8
Mode 10	DCI format 1A	common and UE specific	Single antenna port, port 7
	DCI format 2D	UE specific	Single antenna port, port 7 or 8

Table 6 below shows a DCI format and a search area of a control channel used when temporary C-RNTI is masked to the CRC of the DCI.

TABLE 6

DCI format	search space	Transmission mode of PDSCH based on PDCCH
DCI format 1A	common and UE specific	If the number of PBCH transmission ports is 1, single antenna port, port 0, otherwise Transmit diversity
DCI format 1	UE specific	If the number of PBCH transmission ports is 1, single antenna port, port 0, otherwise Transmit diversity

FIG. **7** shows a downlink subframe to which a reference signal and a control channel are allocated in 3GPP LTE.

The downlink subframe may be divided into a control region and a data region. For example, in the downlink subframe, the control region (or a PDCCH region) includes first three OFDM symbols, and the data region in which a PDSCH is transmitted includes the remaining OFDM symbols.

A PCFICH, a PHICH, and/or a PDCCH are transmitted in the control region.

A PHICH (physical HARQ ACK/NACK indicator channel) may transmit HARQ (hybrid automatic retransmission request) information in response to uplink transmission.

A PCFICH (physical control format indicator channel) may transmit information regarding the number of OFDM symbols allocated to the PDCCH. For example, a control format indictor (CFI) of the PCFICH may indicate three OFDM symbols. A region excluding a resource in which the PCFICH and/or the PHICH are transmitted in the control region is a PDCCH region in which the UE monitors the PDCCH.

Various reference signals may be transmitted in the subframe.

A CRS (cell-specific reference signal) is a reference signal that can be received by all UEs in a cell, and may be transmitted across a full downlink frequency band. In FIG. **6**, 'R0' indicates an RE used to transmit a CRS for a first antenna port, 'R1' indicates an RE used to transmit a CRS for a second antenna port, 'R2' indicates an RE used to transmit a CRS for a third antenna port, and 'R3' indicates an RE used to transmit a CRS for a fourth antenna port.

An RS sequence $r_{l,n_s}(m)$ for a CRS is defined as follows.

$$r_{l,ns}(m) = \frac{1}{\sqrt{2}}(1 - 2\cdot c(2m)) + j\frac{1}{\sqrt{2}}(1 - 2\cdot c(2m+1)) \quad \langle\text{Equation 3}\rangle$$

Herein, m=0, 1, . . . , $2N_{RB}^{max,DL}-1$. $N_{RB}^{max,DL}$ is the maximum number of RBs. ns is a slot number in a radio frame. 1 is an OFDM symbol index in a slot.

A pseudo-random sequence is defined by a length-31 gold sequence as follows.

$$c(n)=(x_1(n+Nc)+x_2(n+Nc))\bmod 2$$

$$x_1(n+31)=(x_1(n+3)+x_1(n))\bmod 2$$

$$x_2(n+31)=(x_2(n+3)+x_2(n+2)+x_2(n+1)+x_2(n))\bmod 2 \quad \langle\text{Equation 4}\rangle$$

Herein, Nc=1600, and a first m-sequence is initialized as x1(0)=1, x1(n)=0, m=1, 2, . . . , 30. A second m-sequence is initialized as $c_{init}=2^{10}\cdot(7\cdot(n_s+1)+l+1)\cdot(2\cdot N_{ID}^{cell}+1)+2\cdot N_{ID}^{cell}+N_{CP}$ at a start of each OFDM symbol. N_{ID}^{cell} is a physical cell identifier (PCI). N_{CP} is set to $N_{CP}=1$ in a normal CP case, and is set to $N_{CP}=0$ in an extended CP case.

In addition, a URS (UE-specific Reference Signal) may be transmitted in the subframe. Whereas the CRS is transmitted in a full region of the subframe, the URS is a reference signal transmitted in a data region of the subframe and is used to demodulate the PDSCH. In FIG. **7**, 'R5' indicates an RE used to transmit the URS. A DM-RS is a reference signal used to demodulate EPDCCH data.

The URS may be transmitted in an RB in which resource mapping is performed on corresponding PDSCH data. Although R5 is indicated in FIG. **7** in addition to a region in which the PDSCH data is transmitted, this is for indicating a location of an RE to which the URS is mapped.

The URS may be a reference signal which is demodulated only by a specific UE. An RS (reference signal) sequence $r_{l,n_s}(m)$ for the URS is equivalent to Equation 3. In this case, $m=0, 1, \ldots, 12N_{RB}^{PDSCH}-1$, and N_{RB}^{PDSCH} is the number of RBs used for transmission of a corresponding PDSCH. If the URS is transmitted through a single antenna, a pseudo-random sequence generator is initialized as $c_{init}=(\lfloor n_s/2\rfloor+1)\cdot(2N_{ID}^{cell}+1)\cdot 2^{16}+n_{RNTI}$ at a start of each subframe. n_{RNTI} is an identifier of a wireless device.

The aforementioned initialization method is for a case where the URS is transmitted through the single antenna, and when the URS is transmitted through multiple antennas, the pseudo-random sequence generator is initialized as $c_{init}=(\lfloor n_s/2\rfloor+1)\cdot(2n_{ID}^{(n_{SCID})}+1)\cdot 2^{16}+n_{SCID}$ at a start of each subframe. n_{SCID} is a parameter acquired from a DL (downlink) grant (e.g., a DCI format 2B or 2C) related to PDSCH transmission.

The URS supports MIMO (Multiple Input Multiple Output) transmission. According to an antenna port or a layer, an RS sequence for the URS may be spread into a spread sequence as follows.

TABLE 7

Layer	[w(0) w(1) w(2) w(3)]
1	[+1 +1 +1 +1]
2	[+1 −1 +1 −1]
3	[+1 +1 +1 +1]
4	[+1 −1 +1 −1]
5	[+1 +1 −1 −1]
6	[−1 −1 +1 +1]
7	[+1 −1 −1 +1]
8	[−1 +1 +1 −1]

A layer may be defined as an information path which is input to a precoder. A rank is a non-zero eigenvalue of a MIMO channel matrix, and is equal to the number of layers or the number of spatial streams. The layer may correspond to an antenna port for identifying a URS and/or a spread sequence applied to the URS.

Meanwhile, the PDCCH is monitored in an area restricted to the control region in the subframe, and a CRS transmitted in a full band is used to demodulate the PDCCH. As a type of control data is diversified and an amount of control data is increased, scheduling flexibility is decreased when using only the existing PDCCH. In addition, in order to decrease an overhead caused by CRS transmission, an EPDCCH (enhanced PDCCH) is introduced.

FIG. **8** is an example of a subframe having an EPDCCH.

The subframe may include zero or one PDCCH region **810** and zero or more EPDCCH regions **820** and **830**.

The EPDCCH regions **820** and **830** are regions in which a UE monitors the EPDCCH. The PDCCH region **810** is located in first three or up to 4 OFDM symbols of the subframe, whereas the EPDCCH regions **820** and **830** may be flexibly scheduled in an OFDM symbol located after the PDCCH region **810**.

One or more EPDCCH regions **820** and **830** may be assigned to the UE. The UE may monitor EPDDCH data in the assigned EPDCCH regions **820** and **830**.

The number/location/size of the EPDCCH regions **820** and **830** and/or information regarding a subframe for monitoring the EPDCCH may be reported by a BS to the UE by using an RRC (radio resource control) message or the like.

In the PDCCH region **810**, a PDCCH may be demodulated on the basis of a CRS. In the EPDCCH regions **820** and **830**, instead of the CRS, a DM-RS may be defined for demodulation of the EPDCCH. The DM-RS may be transmitted in corresponding EPDCCH regions **820** and **830**.

An RS sequence for the DM-RS is equivalent to Equation 3. In this case, $m=0, 1, \ldots, 12N_{RB}^{max,DL}-1$, and $N_{RB}^{max,DL}$ is a maximum number of RBs. A pseudo-random sequence generator may be initialized as $c_{init}=(\lfloor n_s/2\rfloor+1)\cdot(2n_{ID,i}^{EPDCCH}+1)\cdot 2^{16}+n_{SCID}^{EPDCCH}$ at a start of each subframe. ns is a slot number of a radio frame. $n_{ID,i}^{EPDCCH}$ is a cell index related to a corresponding EPDCCH region. n_{SCID}^{EPDCCH} is a parameter given from higher layer signaling.

Each of the EPDCCH regions **820** and **830** may be used to schedule a different cell. For example, an EPDCCH in the EPDCCH region **820** may carry scheduling information for a primary cell, and an EPDCCH in the EPDCCH region **830** may carry scheduling information for a secondary cell.

When the EPDCCH is transmitted through multiple antennas in the EPDCCH regions **820** and **830**, the same precoding as that used in the EPDCCH may be applied to a DM-RS in the EPDCCH regions **820** and **830**.

Comparing with a case where the PDCCH uses a CCE as a transmission resource unit, a transmission resource unit for the EPDCCH is called an ECCE (Enhanced Control Channel Element). An aggregation level may be defined as a resource unit for monitoring the EPDCCH. For example, when 1 ECCE is a minimum resource for the EPDCCH, it may be defined as an aggregation level L={1, 2, 4, 8, 16}. A search space may also be defined in an EPDCCH region. The UE may monitor an EPDCCH candidate on the basis of the aggregation level.

FIG. **9** shows the concept of a method of processing a downlink transport channel according to an embodiment of the present invention.

In FIG. **9**, an operation of delivering a transport block to a physical layer via a transport channel is described.

An LTE physical layer uses a higher layer, i.e., a MAC layer and a transport channel, to provide an interface. In case of single-antenna transmission, one transport block having a dynamic size exists for each TTI (transmission time interval). For example, in case of multi-antenna transmission, a transport block having a dynamic size may exist in plural (e.g., up to two) for each TTI.

In FIG. **9**, a processing procedure for DL-SCH transmission is described when performing an LTE downlink transmission process. A second processing procedure corresponding to a second transport block exists only in case of downlink spatial multiplexing. In the case of downlink spatial multiplexing, two transport blocks each having a different size may be combined through antenna mapping in general. Hereinafter, an LTE downlink transport channel processing method of FIG. **14** is described.

(1) Inserting CRC Per Transport Block

In a first step of transport channel processing, a 24-bit CRC may be calculated and attached to each transport block. By using the CRC, an error may be detected in a decoded transport block in a receiving end. When the detected error is reported and thus retransmission is requested, for example, a downlink HARQ protocol may be used.

(2) Segmenting Code Block and Inserting CRC Per Transport Block

An internal interleaver of an LTE turbo code may be restricted in a size thereof, and thus may be defined only for a code block size of which a maximum block size is limited to a specific bit. If a size of a transport block including a CRC attached to the transport block exceeds a maximum code block size, code block segmentation may be performed before turbo coding. The segmentation of the code block implies that the transport block is divided into smaller sized code blocks to conform to code block sizes defined in a turbo code.

FIG. **10** shows the concept of a method of performing code block segmentation.

Referring to FIG. **10**, code block segmentation may imply that an additional CRC is calculated and attached for each code block. A code block which is correctly coded can be known more rapidly when each code block has a CRC. Accordingly, iterative decoding on a corresponding code block can be finished more rapidly. Therefore, processing power consumption of a UE can be decreased. If one transport block is one code block in the absence of the code block segmentation, the CRC may not be added to the code block.

In the presence of the code block segmentation, whether the entirety of the transport block is correctly received can also be known indirectly from each of code block CRCs. In addition, by performing additional error detection based on the transport block CRC, it is possible to decrease a risk in which an error is not detected from a decoded transport block.

(3) Turbo Coding

In LTE, the existing WCDMA/HSPA turbo encoder internal interleaver is replaced with QPP (quadrature permutation polynomial)-based interleaving. Unlike the interleaver of the WCDMA/HSPA turbo code, the QPP-based interleaver is a maximum contention-free interleaver, and thus parallelization of a decoding process is possible simply without a collision risk even if different parallel processes access to an interleaver memory.

(4) Rate Matching and Physical Layer HARQ Function

Rate matching and physical layer HARQ take a role of correctly determining bits to be transmitted within a given TTI from blocks of code bits delivered from a channel encoder. Outputs of the turbo encoder (i.e., systematic bits, first parity bits, and second parity bits) may be preferentially interleaved respectively. The interleaved bits may enter to a circular buffer. A bit selection block extracts consecutive bits from the circular buffer by an amount of allocated resources.

FIG. **11** shows the concept of a method of performing rate matching.

Referring to FIG. **11**, since a constant amount of radio resources are used in actual transmission, to cope with this situation, rate matching must be performed on an encoded code block. In general, the rate matching is achieved through puncturing or repetition. The rate matching may be performed in unit of an encoded code block such as WCDMA of 3GPP. It is shown in FIG. **11** that the method is performed separately on a system bit part and a parity bit part of the encoded code block. It is assumed herein that a code rate is ⅓.

(5) Bit-Based Scrambling

LTE downlink scrambling implies that a block of code bits subjected to rate matching and HARQ is multiplied by a bit-based scrambling sequence. In LTE, downlink scrambling may be applied to a coded bit of each transport channel.

(6) Data Modulation

Downlink data modulation indicates a process of converting scrambled bits into complex-valued modulation symbols. Examples of a modulation scheme supported in an LTE downlink include QPSK, 16QAM, and 64QAM. Hereinafter, a case where 256 QAM is additionally supported as the modulation scheme will be described in the exemplary embodiment of the present invention. The modulation scheme may use 2 bits, 4 bits, and 6 bits respectively for QPSK, 16QAM, and 64QAM. Different modulation schemes may be used according to a transport channel.

(7) Antenna Mapping

In general, antenna mapping takes a role of simultaneously processing modulation symbols corresponding to two transport blocks and of mapping results thereof to different antenna ports.

(8) Resource Block Mapping

Resource block mapping takes a role of mapping symbols to be transmitted to respective antenna ports to a resource element of resource blocks allocated to transport blocks transmitted to a UE by using a MAC scheduler.

Some resource elements in the resource block are preoccupied by different antenna ports or control regions, and such resource elements cannot be used.

A BS may use a downlink control channel (e.g., PDCCH, EPDCCH) to deliver a data block size to a UE. Information on the data block size transmitted through a PDSCH may be transmitted based on resource allocation information and MCS which is modulation and coding rate related information. For an MCS field, MCS information may be transmitted to the UE on the basis of 5 bits for example. For resource allocation, one RB to 110 RBs may be allocated. If all of the 5 bits of the MCS field are used to transmit the MCS information without having to use MIMO, 32 pieces of MCS information may be transmitted based on the 5 bits. In this case, signaling is possible for a data block size corresponding to 32×110. However, since 3 pieces of MCS information out of the 32 pieces of MCS information are used to indicate a change of a modulation scheme when performing retransmission, signaling is actually possible for a data block size corresponding to 29×110. The data block may imply a transport block.

QPSK, 16QAM, and 64QAM may be used as a modulation scheme supported in the existing LTE system. At a switching point at which the modulation scheme is changed, the same data block size may be indicated when the same resource is allocated. This is to effectively perform an operation in various channel environments. In order to indicate an actual data block size, IMCS which is MCS related information transmitted through a downlink control channel may be mapped to ITBS which is another variable for indicating a data block size. Table 8 below shows a relation between IMCS and ITBS.

TABLE 8

MCS Index I_{MCS}	Modulation Order Q_m	TBS Index I_{TBS}
0	2	0
1	2	1
2	2	2
3	2	3
4	2	4
5	2	5
6	2	6
7	2	7
8	2	8
9	2	9
10	4	9
11	4	10
12	4	11
13	4	12
14	4	13
15	4	14
16	4	15
17	6	15
18	6	16

TABLE 8-continued

MCS Index I_{MCS}	Modulation Order Q_m	TBS Index I_{TBS}
19	6	17
20	6	18
21	6	19
22	6	20
23	6	21
24	6	22
25	6	23
26	6	24
27	6	25
28	6	26
29	2	reserved
30	4	
31	6	

The transport block size transmitted in a downlink may be determined by combining a resource allocation and an MCS field transmitted through the downlink control channel. Table 9 and Table 10 below respectively show a transport block size in the aforementioned IMCS-to-ITBS relation of Table 8 respectively for resource allocation of 1 RB to 10 RBs and resource allocation of 101 RBs to 110 RBs.

TABLE 9

	N_{PRB}									
I_{TBS}	1	2	3	4	5	6	7	8	9	10
0	16	32	56	88	120	152	176	208	224	256
1	24	56	88	144	176	208	224	256	328	344
2	32	72	144	176	208	256	296	328	376	424
3	40	104	176	208	256	328	392	440	504	568
4	56	120	208	256	328	408	488	552	632	696
5	72	144	224	328	424	504	600	680	776	872
6	328	176	256	392	504	600	712	808	936	1032
7	104	224	328	472	584	712	840	968	1096	1224
8	120	256	392	536	680	808	968	1096	1256	1384
9	136	296	456	616	776	936	1096	1256	1416	1544
10	144	328	504	680	872	1032	1224	1384	1544	1736
11	176	376	584	776	1000	1192	1384	1608	1800	2024
12	208	440	680	904	1128	1352	1608	1800	2024	2280
13	224	488	744	1000	1256	1544	1800	2024	2280	2536
14	256	552	840	1128	1416	1736	1992	2280	2600	2856
15	280	600	904	1224	1544	1800	2152	2472	2728	3112
16	328	632	968	1288	1608	1928	2280	2600	2984	3240
17	336	696	1064	1416	1800	2152	2536	2856	3240	3624
18	376	776	1160	1544	1992	2344	2792	3112	3624	4008
19	408	840	1288	1736	2152	2600	2984	3496	3880	4264
20	440	904	1384	1864	2344	2792	3240	3752	4136	4584
21	488	1000	1480	1992	2472	2984	3496	4008	4584	4968
22	520	1064	1608	2152	2664	3240	3752	4264	4776	5352
23	552	1128	1736	2280	2856	3496	4008	4584	5160	5736
24	584	1192	1800	2408	2984	3624	4264	4968	5544	5992
25	616	1256	1864	2536	3112	3752	4392	5160	5736	6200
26	712	1480	2216	2984	3752	4392	5160	5992	6712	7480

TABLE 10

	N_{PRB}									
I_{TBS}	101	102	103	104	105	106	107	108	109	110
0	2792	2856	2856	2856	2984	2984	2984	2984	2984	3112
1	3752	3752	3752	3752	3880	3880	3880	4008	4008	4008
2	4584	4584	4584	4584	4776	4776	4776	4776	4968	4968
3	5992	5992	5992	5992	6200	6200	6200	6200	6456	6456
4	7224	7224	7480	7480	7480	7480	7736	7736	7736	7992
5	8760	9144	9144	9144	9144	9528	9528	9528	9528	9528
6	10680	10680	10680	10680	11064	11064	11064	11448	11448	11448
7	12216	12576	12576	12576	12960	12960	12960	12960	13536	13536
8	14112	14112	14688	14688	14688	14688	15264	15264	15264	15264
9	15840	16416	16416	16416	16416	16992	16992	16992	16992	17568
10	17568	18336	18336	18336	18336	18336	19080	19080	19080	19080
11	20616	20616	20616	21384	21384	21384	21384	22152	22152	22152
12	22920	23688	23688	23688	23688	24496	24496	24496	24496	25456
13	26416	26416	26416	26416	27376	27376	27376	27376	28336	28336
14	29296	29296	29296	29296	30576	30576	30576	30576	31704	31704
15	30576	31704	31704	31704	31704	32856	32856	32856	34008	34008
16	32856	32856	34008	34008	34008	34008	35160	35160	35160	35160
17	36696	36696	36696	37888	37888	37888	39232	39232	39232	39232
18	40576	40576	40576	40576	42368	42368	42368	42368	43816	43816
19	43816	43816	43816	45352	45352	45352	46888	46888	46888	46888
20	46888	46888	48936	48936	48936	48936	48936	51024	51024	51024

TABLE 10-continued

	N_{PRB}									
I_{TBS}	101	102	103	104	105	106	107	108	109	110
21	51024	51024	51024	52752	52752	52752	52752	55056	55056	55056
22	55056	55056	55056	57336	57336	57336	57336	59256	59256	59256
23	57336	59256	59256	59256	59256	61664	61664	61664	61664	63776
24	61664	61664	63776	63776	63776	63776	66592	66592	66592	66592
25	63776	63776	66592	66592	66592	66592	68808	68808	68808	71112
26	75376	75376	75376	75376	75376	75376	75376	75376	75376	75376

In the embodiment of the present invention, a method of determining a size of transport block (or data block) is described when 256QAM is supported as a modulation scheme other than QPSK, 16QAM, and 64QAM supported in the existing LTE system.

The size of transport block may be determined by distinguishing a case where the transport block is subjected to channel coding as a single code block without being segmented in a process of code block segmentation and per-code block CRC insertion and a case where the transport block is subjected to channel coding by being segmented into multiple code blocks. If the transport block size including a CRC attached to the transport block exceeds a maximum code block size, the code block segmentation may be performed before turbo coding. The segmentation of code block implies that the transport block is segmented into smaller-sized code blocks to conform to a code block size defined in the turbo code.

In a case where channel coding is performed with the single code block without being segmented in the process of code block segmentation and per-code block CRC insertion, the transport block size may be determined according to an internal interleaver size of a turbo code in order not to attach a dummy bit to the code block.

Table 11 below shows the size of the turbo code internal interleaver.

TABLE 11

i	L
1	40
2	48
3	56
4	64
5	72
6	80
7	88
8	96
9	104
10	112
11	120
12	128
13	136
14	144
15	152
16	160
17	168
18	176
19	184
20	192
21	200
22	208
23	216
24	224
25	232
26	240
27	248
28	256
29	264

TABLE 11-continued

i	L
30	272
31	280
32	288
33	296
34	304
35	312
36	320
37	328
38	336
39	344
40	352
41	360
42	368
43	376
44	384
45	392
46	400
47	408
48	416
49	424
50	432
51	440
52	448
53	456
54	464
55	472
56	480
57	488
58	496
59	504
60	512
61	528
62	544
63	560
64	576
65	592
66	608
67	624
68	640
69	656
70	672
71	688
72	704
73	720
74	736
75	752
76	768
77	784
78	800
79	816
80	832
81	848
82	864
83	880
84	896
85	912
86	928
87	944
88	960
89	976
90	992
91	1008

TABLE 11-continued

i	L
92	1024
93	1056
94	1088
95	1120
96	1152
97	1184
98	1216
99	1248
100	1280
101	1312
102	1344
103	1376
104	1408
105	1440
106	1472
107	1504
108	1536
109	1568
110	1600
111	1632
112	1664
113	1696
114	1728
115	1760
116	1792
117	1824
118	1856
119	1888
120	1920
121	1952
122	1984
123	2016
124	2048
125	2112
126	2176
127	2240
128	2304
129	2368
130	2432
131	2496
132	2560
133	2624
134	2688
135	2752
136	2816
137	2880
138	2944
139	3008
140	3072
141	3136
142	3200
143	3264
144	3328
145	3392
146	3456
147	3520
148	3584
149	3648
150	3712
151	3776
152	3840
153	3904
154	3968
155	4032
156	4096
157	4160
158	4224
159	4288
160	4352
161	4416
162	4480
163	4544
164	4608
165	4672
166	4736
167	4800
168	4864
169	4928
170	4992
171	5056
172	5120
173	5184
174	5248
175	5312
176	5376
177	5440
178	5504
179	5568
180	5632
181	5696
182	5760
183	5824
184	5888
185	5952
186	6016
187	6080
188	6144

In Table 11, i may denote an index of a turbo code internal interleaver, and L may denote a size of the turbo code internal interleaver. According to the embodiment of the present invention, the transport block size may be defined according to the size of the turbo code internal interleaver. That is, the dummy bit may be removed by limiting the transport block size to L.

Bits input to the turbo code internal interleaver may be denoted by $c_0, c_1, \ldots, c_{L-1}$. Herein, L denotes the number of input bits as a transport block size. Output bits calculated via the turbo code internal interleaver may be denoted by $c_0', c_1', \ldots, c_{L-1}'$. The input bit and the output bit may satisfy the relation of Equation 5 below.

$$c_i'=c_{\Pi(i)}, i=0,1,\ldots,(L-1) \qquad \text{<Equation 5>}$$

Herein, an output index i and an input index Π(i) may satisfy Equation 6 below.

$$\Pi(i)=(f_1 \cdot i+f_2 \cdot i^2) \bmod L \qquad \text{<Equation 6>}$$

In Equation 6, a parameter f_1 and a parameter f_2 may be values determined by a table on the basis of a size L of a turbo code internal interleaver (or a size of a transport block).

According to the embodiment of the present invention, the dummy bit may be removed in channel coding if the transport block size is defined to be equal to the turbo code internal interleaver size L defined in Table 11. It is assumed herein that the size of the transport block input to the turbo code internal interleaver is a size considering CRC attachment. For example, if a 24-bit CRC is attached, the transport block size is L-24 which is obtained by subtracting 24 bits from the block size defined in Table 11. That is, in the embodiment of the present invention, the dummy bit may be removed by defining the transport block size to N=L−A. Herein, N, L, and A may respectively denote the transport block size, the turbo code internal interleaver size, and the CRC-bit size.

If channel coding is performed by segmenting the transport block into multiple code blocks, the transport block size may be determined as follows. If the transport block is segmented into two or more code blocks, a CRC is attached to the transport block, and the CRC may also be attached to each segmented code block. When performing turbo coding on the transport block, a size corresponding to a sum of the code block size and a size of CRC attached to the code block must be set to the same as the internal interleaver size defined in Table 11 described above. In addition, it may be determined such that an error rate is not different between code blocks by equally setting the size of the segmented code block.

Then, if it is assumed that a transport block with a size N is segmented into M (M>=2) code blocks each having a size L (where L is a size of a turbo code internal interleaver) and a CRC size is A (e.g., 24 bits), Equation 7 below must be satisfied so that the code blocks have the same size.

$$N+A\times M+24=M^*(L+A)$$

$$N=M\times L-A \quad \text{<Equation 7>}$$

The transport block size may be calculated by using Equation 7. The values L and M may be calculated by considering the defined turbo code internal interleaver size, and may be determined such that a dummy bit is not generated when performing turbo coding on each code block.

Table 12 below shows a case where there are up to 24 code blocks among transport blocks satisfying the aforementioned condition. It is assumed in Table 12 that a CRC size is 24, and if the CRC size is changed, another value may be determined to the transport block size.

TABLE 12

M	N
2	6200
2	6328
2	6456
2	6584
2	6712
2	6840
2	6968
2	7096
2	7224
2	7352
2	7480
2	7608
2	7736
2	7864
2	7992
2	8120
2	8248
2	8376
2	8504
2	8632
2	8760
2	8888
2	9016
2	9144
2	9272
2	9400
2	9528
2	9656
2	9784
2	9912
2	10040
2	10168
2	10296
2	10424
2	10552
2	10680
2	10808
2	10936
2	11064
2	11192
2	11320
2	11448
2	11576
2	11704
2	11832
2	11960
2	12088
2	12216
3	12384
3	12576
3	12768
3	12960
3	13152

TABLE 12-continued

M	N
3	13344
3	13536
3	13728
3	13920
3	14112
3	14304
3	14496
3	14688
3	14880
3	15072
3	15264
3	15456
3	15648
3	15840
3	16032
3	16224
3	16416
3	16608
3	16800
3	16992
3	17184
3	17376
3	17568
3	17760
3	17952
3	18144
3	18336
3	12384
4	18568
4	18824
4	19080
4	19336
4	19592
4	19848
4	20104
4	20360
4	20616
4	20872
4	21128
4	21384
4	21640
4	21896
4	22152
4	22408
4	22664
4	22920
4	23176
4	23432
4	23688
4	23944
4	24200
4	24456
5	24496
5	24816
5	25136
5	25456
5	25776
5	26096
5	26416
5	26736
5	27056
5	27376
5	27696
5	28016
5	28336
5	28656
5	28976
5	29296
5	29616
5	29936
5	30256
5	30576
6	30936
5	31320
5	31704
6	32088
6	32472
6	32856

TABLE 12-continued

M	N
6	33240
6	33624
6	34008
6	34392
6	34776
6	35160
6	35544
6	35928
6	36312
6	36696
6	30936
6	31320
7	36992
7	37440
7	37888
7	38336
7	38784
7	39232
7	39680
7	40128
7	40576
7	41024
7	41472
7	41920
7	42368
7	42816
7	36992
8	42792
8	43304
8	43816
8	44328
8	44840
8	45352
8	45864
8	46376
8	46888
8	47400
8	47912
8	48424
8	49320
9	49296
9	49872
9	50448
9	51024
9	51600
9	52176
9	52752
9	53328
9	53904
9	54480
9	55488
10	55416
10	56056
10	56696
10	57336
10	57976
10	58616
10	59256
10	59896
10	60536
10	61656
11	61664
11	62368
11	63072
11	63776
11	64480
11	65184
11	65888
11	66592
11	67824
12	68040
12	68808
12	69576
12	70344
12	71112
12	71880
12	72648
12	73992
13	74544
13	75376
13	76208
13	77040
13	77872
13	78704
13	80160
14	80280
14	81176
14	82072
14	82968
14	83864
14	84760
14	85656
14	80280
14	81176
15	86016
15	86976
15	87936
15	88896
15	89856
15	90816
15	91776
16	92776
16	93800
16	94824
16	95848
16	96872
16	97896
17	98576
17	99664
17	100752
17	101840
17	102928
17	104016
18	104376
18	105528
18	106680
18	107832
18	108984
18	110136
19	111392
19	112608
19	113824
19	115040
19	116256
20	117256
20	118536
20	119816
20	121096
20	123336
21	124464
21	125808
21	127152
21	129504
22	130392
22	131800
22	133208
22	134616
23	136320
23	137792
23	139264
23	140736
24	142248
24	143784
24	145320
24	146856

In Table 12, M denotes the number of code blocks segmented from one transport block, and N denotes a size of transport block. The size of transport block may be set differently according to the number of segmented code blocks.

When using the size of transport block defined in Table 11 and Table 12, a dummy bit may not be generated when performing channel coding. Accordingly, the same performance may be guaranteed between code blocks. Therefore, according to the embodiment of the present invention, the size of transport block may be calculated and used on the basis of Equation 6 and Equation 7 depending on the number of code blocks segmented from one transport block.

For example, on the basis of a combination of a modulation and coding rate and an allocation resource size, a BS may report to a UE about information on a size of transport block transmitted by the BS. The size of transport block may be expressed with the combination of the modulation and coding rate and the allocated resource size. The BS may determine the modulation and coding rate to be applied to a coded block by referring to a channel quality indicator transmitted by the UE. A size of resource allocated to the coded block may also be determined by considering a resource for transmitting control information and a resource for a reference signal for channel estimation.

FIG. **12** shows the concept of a resource block pair according to an embodiment of the present invention.

Referring to FIG. **12**, a horizontal axis represents a time domain, and a vertical axis represents a frequency domain.

In the resource block pair of FIG. **12**, it may be assumed that resources for control information transmission are first three OFDM symbols (i.e., an OFDM symbol 0, an OFDM symbol 1, and an OFDM symbol 2) and reference signals are transmitted through two transmit antennas. In this case, the number of REs (resource elements) that can be used for data transmission may be 120 in one unit RBP (resource block pair).

For example, it may be assumed that a modulation scheme and a coding rate used by a BS are 64QAM and 0.6504 and the number of allocated RBs is 10. A size of transport block that can be transmitted through allocated 10 RBs is 4658 bits. This is a value in the range between 4608 bits and 4672 bits, i.e., the transport block size defined in Table 11 above. By defining a rule for determining the size of transport block to any one of the defined two transport block sizes, the size of transport block may be determined according to various modulation and code rates and allocated resource sizes.

In a case where a size of transport block that can be actually transmitted is not equal to a supportable transport block size as described above, the size of transport block may be determined according to a specific rule. For example, according to the embodiment of the present invention, if the size of transport block is not equal to the supportable transport block size, the size of transport block that can be actually transmitted may be determined by using any one of the following rules.

i) Method of determining a transport block size to a maximum supportable transport block size not exceeding an actually transmissible transport block size.

ii) Method of determining a transport block size to a minimum supportable transport block size exceeding an actually transmissible transport block size.

iii) Method of determining a transport block size to a supportable data block having a smallest difference with respect to an actually transmissible data block size.

Table 13 below shows an example of a case where the number of code blocks is in the range of 25 to 66 among transport blocks satisfying the aforementioned condition. It is shown in Table 13 that a size of transport block is defined variously according to a modulation scheme, a coding rate, and an allocated resource even if the same number of code blocks are present. A transport block defined in a case of using 256QAM as the modulation scheme is also included in Table 13. In Table 13, an uppermost end may indicate the number of code blocks, and a value included in a column mapped according to the number of code blocks may be a size of transport block defined variously according to a modulation and coding rate. According to the embodiment of the present invention, one of the sizes of transport blocks defined in the following table may be used when determining the size of transport block.

TABLE 13

25	26	27	28	29	30	31	32	33
76176	79224	82272	85320	88368	91416	94464	97512	100560
77776	80888	84000	87112	90224	93336	96448	99560	102672
79376	82552	85728	88904	92080	95256	98432	101608	104784
80976	84216	87456	90696	93936	97176	100416	103656	106896
82576	85880	89184	92488	95792	99096	102400	105704	109008
84176	87544	90912	94280	97648	101016	104384	107752	111120
85776	89208	92640	96072	99504	102936	106368	109800	113232
87376	90872	94368	97864	101360	104856	108352	111848	115344
88976	92536	96096	99656	103216	106776	110336	113896	117456
90576	94200	97824	101448	105072	108696	112320	115944	119568
92176	95864	99552	103240	106928	110616	114304	117992	121680
93776	97528	101280	105032	108784	112536	116288	120040	123792
95376	99192	103008	106824	110640	114456	118272	122088	125904
96976	100856	104736	108616	112496	116376	120256	124136	128016
98576	102520	106464	110408	114352	118296	122240	126184	130128
100176	104184	108192	112200	116208	120216	124224	128232	132240
101776	105848	109920	113992	118064	122136	126208	130280	134352
103376	107512	111648	115784	119920	124056	128192	132328	136464
104976	109176	113376	117576	121776	125976	130176	134376	138576
106576	110840	115104	119368	123632	127896	132160	136424	140688
108176	112504	116832	121160	125488	129816	134144	138472	142800
109776	114168	118560	122952	127344	131736	136128	140520	144912
111376	115832	120288	124744	129200	133656	138112	142568	147024
112976	117496	122016	126536	131056	135576	140096	144616	149136
114576	119160	123744	128328	132912	137496	142080	146664	151248
116176	120824	125472	130120	134768	139416	144064	148712	153360
117776	122488	127200	131912	136624	141336	146048	150760	155472
119376	124152	128928	133704	138480	143256	148032	152808	157584
120976	125816	130656	135496	140336	145176	150016	154856	159696
122576	127480	132384	137288	142192	147096	152000	156904	161808
124176	129144	134112	139080	144048	149016	153984	158952	163920
125776	130808	135840	140872	145904	150936	155968	161000	166032
127376	132472	137568	142664	147760	152856	157952	163048	168144

TABLE 13-continued

128976	134136	139296	144456	149616	154776	159936	165096	170256
130576	135800	141024	146248	151472	156696	161920	167144	172368
132176	137464	142752	148040	153328	158616	163904	169192	174480
133776	139128	144480	149832	155184	160536	165888	171240	176592
135376	140792	146208	151624	157040	162456	167872	173288	178704
136976	142456	147936	153416	158896	164376	169856	175336	180816
138576	144120	149664	155208	160752	166296	171840	177384	182928
140176	145784	151392	157000	162608	168216	173824	179432	185040
141776	147448	153120	158792	164464	170136	175808	181480	187152
143376	149112	154848	160584	166320	172056	177792	183528	189264
144976	150776	156576	162376	168176	173976	179776	185576	191376
146576	152440	158304	164168	170032	175896	181760	187624	193488
148176	154104	160032	165960	171888	177816	183744	189672	195600
149776	155768	161760	167752	173744	179736	185728	191720	197712
151376	157432	163488	169544	175600	181656	187712	193768	199824
152976	159096	165216	171336	177456	183576	189696	195816	201936
34	35	36	37	38	39	40	41	42
103608	106656	109704	112752	115800	118848	121896	124944	127992
105784	108896	112008	115120	118232	121344	124456	127568	130680
107960	111136	114312	117488	120664	123840	127016	130192	133368
110136	113376	116616	119856	123096	126336	129576	132816	136056
112312	115616	118920	122224	125528	128832	132136	135440	138744
114488	117856	121224	124592	127960	131328	134696	138064	141432
116664	120096	123528	126960	130392	133824	137256	140688	144120
118840	122336	125832	129328	132824	136320	139816	143312	146808
121016	124576	128136	131696	135256	138816	142376	145936	149496
123192	126816	130440	134064	137688	141312	144936	148560	152184
125368	129056	132744	136432	140120	143808	147496	151184	154872
127544	131296	135048	138800	142552	146304	150056	153808	157560
129720	133536	137352	141168	144984	148800	152616	156432	160248
131896	135776	139656	143536	147416	151296	155176	159056	162936
134072	138016	141960	145904	149848	153792	157736	161680	165624
136248	140256	144264	148272	152280	156288	160296	164304	168312
138424	142496	146568	150640	154712	158784	162856	166928	171000
140600	144736	148872	153008	157144	161280	165416	169552	173688
142776	146976	151176	155376	159576	163776	167976	172176	176376
144952	149216	153480	157744	162008	166272	170536	174800	179064
147128	151456	155784	160112	164440	168768	173096	177424	181752
149304	153696	158088	162480	166872	171264	175656	180048	184440
151480	155936	160392	164848	169304	173760	178216	182672	187128
153656	158176	162696	167216	171736	176256	180776	185296	189816
155832	160416	165000	169584	174168	178752	183336	187920	192504
158008	162656	167304	171952	176600	181248	185896	190544	195192
160184	164896	169608	174320	179032	183744	188456	193168	197880
162360	167136	171912	176688	181464	186240	191016	195792	200568
164536	169376	174216	179056	183896	188736	193576	198416	203256
166712	171616	176520	181424	186328	191232	196136	201040	205944
168888	173856	178824	183792	188760	193728	198696	203664	208632
171064	176096	181128	186160	191192	196224	201256	206288	211320
173240	178336	183432	188528	193624	198720	203816	208912	214008
175416	180576	185736	190896	196056	201216	206376	211536	216696
177592	182816	188040	193264	198488	203712	208936	214160	219384
179768	185056	190344	195632	200920	206208	211496	216784	222072
181944	187296	192648	198000	203352	208704	214056	219408	224760
184120	189536	194952	200368	205784	211200	216616	222032	227448
186296	191776	197256	202736	208216	213696	219176	224656	230136
188472	194016	199560	205104	210648	216192	221736	227280	232824
190648	196256	201864	207472	213080	218688	224296	229904	235512
192824	198496	204168	209840	215512	221184	226856	232528	238200
195000	200736	206472	212208	217944	223680	229416	235152	240888
197176	202976	208776	214576	220376	226176	231976	237776	243576
199352	205216	211080	216944	222808	228672	234536	240400	246264
201528	207456	213384	219312	225240	231168	237096	243024	248952
203704	209696	215688	221680	227672	233664	239656	245648	251640
205880	211936	217992	224048	230104	236160	242216	248272	254328
208056	214176	220296	226416	232536	238656	244776	250896	257016
43	44	45	46	47	48	49	50	51
131040	134088	137136	140184	143232	146280	149328	152376	155424
133792	136904	140016	143128	146240	149352	152464	155576	158688
136544	139720	142896	146072	149248	152424	155600	158776	161952
139296	142536	145776	149016	152256	155496	158736	161976	165216
142048	145352	148656	151960	155264	158568	161872	165176	168480
144800	148168	151536	154904	158272	161640	165008	168376	171744
147552	150984	154416	157848	161280	164712	168144	171576	175008
150304	153800	157296	160792	164288	167784	171280	174776	178272
153056	156616	160176	163736	167296	170856	174416	177976	181536

TABLE 13-continued

155808	159432	163056	166680	170304	173928	177552	181176	184800
158560	162248	165936	169624	173312	177000	180688	184376	188064
161312	165064	168816	172568	176320	180072	183824	187576	191328
164064	167880	171696	175512	179328	183144	186960	190776	194592
166816	170696	174576	178456	182336	186216	190096	193976	197856
169568	173512	177456	181400	185344	189288	193232	197176	201120
172320	176328	180336	184344	188352	192360	196368	200376	204384
175072	179144	183216	187288	191360	195432	199504	203576	207648
177824	181960	186096	190232	194368	198504	202640	206776	210912
180576	184776	188976	193176	197376	201576	205776	209976	214176
183328	187592	191856	196120	200384	204648	208912	213176	217440
186080	190408	194736	199064	203392	207720	212048	216376	220704
188832	193224	197616	202008	206400	210792	215184	219576	223968
191584	196040	200496	204952	209408	213864	218320	222776	227232
194336	198856	203376	207896	212416	216936	221456	225976	230496
197088	201672	206256	210840	215424	220008	224592	229176	233760
199840	204488	209136	213784	218432	223080	227728	232376	237024
202592	207304	212016	216728	221440	226152	230864	235576	240288
205344	210120	214896	219672	224448	229224	234000	238776	243552
208096	212936	217776	222616	227456	232296	237136	241976	246816
210848	215752	220656	225560	230464	235368	240272	245176	250080
213600	218568	223536	228504	233472	238440	243408	248376	253344
216352	221384	226416	231448	236480	241512	246544	251576	256608
219104	224200	229296	234392	239488	244584	249680	254776	259872
221856	227016	232176	237336	242496	247656	252816	257976	263136
224608	229832	235056	240280	245504	250728	255952	261176	266400
227360	232648	237936	243224	248512	253800	259088	264376	269664
230112	235464	240816	246168	251520	256872	262224	267576	272928
232864	238280	243696	249112	254528	259944	265360	270776	276192
235616	241096	246576	252056	257536	263016	268496	273976	279456
238368	243912	249456	255000	260544	266088	271632	277176	282720
241120	246728	252336	257944	263552	269160	274768	280376	285984
243872	249544	255216	260888	266560	272232	277904	283576	289248
246624	252360	258096	263832	269568	275304	281040	286776	292512
249376	255176	260976	266776	272576	278376	284176	289976	295776
252128	257992	263856	269720	275584	281448	287312	293176	299040
254880	260808	266736	272664	278592	284520	290448	296376	302304
257632	263624	269616	275608	281600	287592	293584	299576	305568
260384	266440	272496	278552	284608	290664	296720	302776	308832
263136	269256	275376	281496	287616	293736	299856	305976	312096

52	53	54	55	56	57	58	59	60
158472	161520	164568	167616	170664	173712	176760	179808	182856
161800	164912	168024	171136	174248	177360	180472	183584	186696
165128	168304	171480	174656	177832	181008	184184	187360	190536
168456	171696	174936	178176	181416	184656	187896	191136	194376
171784	175088	178392	181696	185000	188304	191608	194912	198216
175112	178480	181848	185216	188584	191952	195320	198688	202056
178440	181872	185304	188736	192168	195600	199032	202464	205896
181768	185264	188760	192256	195752	199248	202744	206240	209736
185096	188656	192216	195776	199336	202896	206456	210016	213576
188424	192048	195672	199296	202920	206544	210168	213792	217416
191752	195440	199128	202816	206504	210192	213880	217568	221256
195080	198832	202584	206336	210088	213840	217592	221344	225096
198408	202224	206040	209856	213672	217488	221304	225120	228936
201736	205616	209496	213376	217256	221136	225016	228896	232776
205064	209008	212952	216896	220840	224784	228728	232672	236616
208392	212400	216408	220416	224424	228432	232440	236448	240456
211720	215792	219864	223936	228008	232080	236152	240224	244296
215048	219184	223320	227456	231592	235728	239864	244000	248136
218376	222576	226776	230976	235176	239376	243576	247776	251976
221704	225968	230232	234496	238760	243024	247288	251552	255816
225032	229360	233688	238016	242344	246672	251000	255328	259656
228360	232752	237144	241536	245928	250320	254712	259104	263496
231688	236144	240600	245056	249512	253968	258424	262880	267336
235016	239536	244056	248576	253096	257616	262136	266656	271176
238344	242928	247512	252096	256680	261264	265848	270432	275016
241672	246320	250968	255616	260264	264912	269560	274208	278856
245000	249712	254424	259136	263848	268560	273272	277984	282696
248328	253104	257880	262656	267432	272208	276984	281760	286536
251656	256496	261336	266176	271016	275856	280696	285536	290376
254984	259888	264792	269696	274600	279504	284408	289312	294216
258312	263280	268248	273216	278184	283152	288120	293088	298056
261640	266672	271704	276736	281768	286800	291832	296864	301896
264968	270064	275160	280256	285352	290448	295544	300640	305736
268296	273456	278616	283776	288936	294096	299256	304416	309576
271624	276848	282072	287296	292520	297744	302968	308192	313416
274952	280240	285528	290816	296104	301392	306680	311968	317256
278280	283632	288984	294336	299688	305040	310392	315744	321096

TABLE 13-continued

281608	287024	292440	297856	303272	308688	314104	319520	324936
284936	290416	295896	301376	306856	312336	317816	323296	328776
288264	293808	299352	304896	310440	315984	321528	327072	332616
291592	297200	302808	308416	314024	319632	325240	330848	336456
294920	300592	306264	311936	317608	323280	328952	334624	340296
298248	303984	309720	315456	321192	326928	332664	338400	344136
301576	307376	313176	318976	324776	330576	336376	342176	347976
304904	310768	316632	322496	328360	334224	340088	345952	351816
308232	314160	320088	326016	331944	337872	343800	349728	355656
311560	317552	323544	329536	335528	341520	347512	353504	359496
314888	320944	327000	333056	339112	345168	351224	357280	363336
318216	324336	330456	336576	342696	348816	354936	361056	367176

61	62	63	64	65	66
185904	188952	192000	195048	198096	201144
189808	192920	196032	199144	202256	205368
193712	196888	200064	203240	206416	209592
197616	200856	204096	207336	210576	213816
201520	204824	208128	211432	214736	218040
205424	208792	212160	215528	218896	222264
209328	212760	216192	219624	223056	226488
213232	216728	220224	223720	227216	230712
217136	220696	224256	227816	231376	234936
221040	224664	228288	231912	235536	239160
224944	228632	232320	236008	239696	243384
228848	232600	236352	240104	243856	247608
232752	236568	240384	244200	248016	251832
236656	240536	244416	248296	252176	256056
240560	244504	248448	252392	256336	260280
244464	248472	252480	256488	260496	264504
248368	252440	256512	260584	264656	268728
252272	256408	260544	264680	268816	272952
256176	260376	264576	268776	272976	277176
260080	264344	268608	272872	277136	281400
263984	268312	272640	276968	281296	285624
267888	272280	276672	281064	285456	289848
271792	276248	280704	285160	289616	294072
275696	280216	284736	289256	293776	298296
279600	284184	288768	293352	297936	302520
283504	288152	292800	297448	302096	306744
287408	292120	296832	301544	306256	310968
291312	296088	300864	305640	310416	315192
295216	300056	304896	309736	314576	319416
299120	304024	308928	313832	318736	323640
303024	307992	312960	317928	322896	327864
306928	311960	316992	322024	327056	332088
310832	315928	321024	326120	331216	336312
314736	319896	325056	330216	335376	340536
318640	323864	329088	334312	339536	344760
322544	327832	333120	338408	343696	348984
326448	331800	337152	342504	347856	353208
330352	335768	341184	346600	352016	357432
334256	339736	345216	350696	356176	361656
338160	343704	349248	354792	360336	365880
342064	347672	353280	358888	364496	370104
345968	351640	357312	362984	368656	374328
349872	355608	361344	367080	372816	378552
353776	359576	365376	371176	376976	382776
357680	363544	369408	375272	381136	387000
361584	367512	373440	379368	385296	391224
365488	371480	377472	383464	389456	395448
369392	375448	381504	387560	393616	399672
373296	379416	385536	391656	397776	403896

All or some of the transport block sizes of Table 13 may be used as a transport block size in a system supporting 256QAM. In addition, some of the transport block sizes of Table 13 support 256QAM, and may be used as a size of transport block transmitted through 2-layer, 3-layer, 4-layer or 5-layer, 6-layer, 7-layer, 8-layer.

According to another embodiment of the present invention, a size of transport block may be determined by differently setting a rank supported depending on a modulation scheme. For example, some of the transport block sizes among the transport block sizes of Table 13 support 256QAM, and may be determined not to support a transport block size greater than or equal to 3-layer as a size of transport block transmitted with a specific rank or below (i.e., 2 layer or below).

FIG. **13** is a flowchart showing a method of performing turbo coding for a transport block according to an embodiment of the present invention.

Referring to FIG. **13**, a size of transport block is determined (step S**1300**).

According to the embodiment of the present invention, an unnecessary dummy bit can be removed by determining the size of transport block according to a size of a turbo code internal interleaver.

The size of transport block may be determined according to whether one transport block is segmented into a single code block or multiple code blocks as described above. If the transport block is segmented into the single code block, the size of transport block may be a value obtained by subtracting a CRC bit size from the turbo code internal interleaver size. If the transport block is segmented into the multiple code blocks, the size of transport block may be a value obtained by subtracting a CRC bit size from a value obtained by multiplying a size of each code block by the number of segmented code blocks. The size of transport block may be determined by additionally considering a modulation scheme (e.g., 64QAM, 256QAM) and an allocation resource.

For turbo coding, the transport block is subjected to code block segmentation (step **S1320**).

In the code block segmentation, a single transport block may be determined to the code block when the single transport block is not segmented into multiple code blocks. If the single transport block is segmented into the multiple code blocks, the single transport block may be determined to the multiple code blocks.

On the basis of the turbo code internal interleaver, data included in the code block is interleaved (step **S1340**).

The turbo code internal interleaver may interleave the data included in the code block. A size of interleaved code block may be a value obtained by considering the turbo code internal interleaver size as described above.

Turbo coding is performed on the interleaved code block (step **S1360**).

The turbo coding may be performed on the interleaved code block. A size of code block may be determined by considering the turbo code internal interleaver size, thereby being able to reduce a dummy bit generated in turbo coding.

FIG. **14** is a block diagram of a wireless communication system according to an embodiment of the present invention.

Referring to FIG. **14**, a BS **1400** includes a processor **1410**, a memory **1420**, and a radio frequency (RF) unit **1430**. The memory **1420** is coupled to the processor **1410**, and stores a variety of information for driving the processor **1410**. The RF unit **1420** is coupled to the processor **1410**, and transmits and/or receives a radio signal. The processor **1410** implements the proposed functions, procedures, and/or methods. In the aforementioned embodiment, an operation of the BS may be implemented by the processor **1410**.

For example, the processor **1410** determines a size of a transport block, divides the transport block into at least one code block based on the size of transport block, interleaves the at least one code block by an interleaver, and performs a turbo coding for the interleaved at least one code block. The processor **1410** may be determined based on the number of the divided code blocks.

A wireless device **1450** includes a processor **1460**, a memory **1470**, and an RF unit **1480**. The memory **1470** is coupled to the processor **1460**, and stores a variety of information for driving the processor **1460**. The RF unit **1480** is coupled to the processor **1460**, and transmits and/or receives a radio signal. The processor **1460** implements the proposed functions, procedures, and/or methods. In the aforementioned embodiment, an operation of the wireless device may be implemented by the processor **1460**.

For example, the processor **1460** determines a size of a transport block, divides the transport block into at least one code block based on the size of transport block, interleaves the at least one code block by an interleaver, and performs a turbo coding for the interleaved at least one code block. The processor **1460** may be determined based on the number of the divided code blocks.

The processor may include an application-specific integrated circuit (ASIC), a separate chipset, a logic circuit, and a data processing unit. The memory may include a read-only memory (ROM), a random access memory (RAM), a flash memory, a memory card, a storage medium, and/or other equivalent storage devices. The RF unit may include a baseband circuit for processing a radio signal. When the embodiment of the present invention is implemented in software, the aforementioned methods can be implemented with a module (i.e., process, function, etc.) for performing the aforementioned functions. The module may be stored in the memory and may be performed by the processor. The memory may be located inside or outside the processor, and may be coupled to the processor by using various well-known means.

Although the aforementioned exemplary system has been described on the basis of a flowchart in which steps or blocks are listed in sequence, the steps of the present invention are not limited to a certain order. Therefore, a certain step may be performed in a different step or in a different order or concurrently with respect to that described above. Further, it will be understood by those ordinary skilled in the art that the steps of the flowcharts are not exclusive. Rather, another step may be included therein or one or more steps may be deleted within the scope of the present invention.

What is claimed is:

1. A method for encoding a transport block in a wireless communication system, the method comprising:

determining, by a first device, a size of the transport block;

attaching, by the first device, a first cyclic redundancy check (CRC) code to the transport block having the determined size to produce a first CRC-attached transport block;

segmenting, by the first device, the first CRC-attached transport block into a plurality of code blocks when a size of the first CRC-attached transport block is larger than a maximum code block size;

attaching, by the first device, a second CRC code to each of the plurality of code blocks to produce a plurality of second CRC-attached code blocks; and

encoding, by the first device, the second CRC-attached code blocks by a turbo-encoder,

wherein the size of the transport block is determined from among a plurality of predetermined transport block sizes,

wherein the size of the transport block is determined based on a 256 quadrature amplitude modulation (QAM) scheme, a size of an allocated resource, and a number of layers, and

wherein the plurality of predetermined transport block sizes includes 305976 bits, 324336 bits, and 391656 bits when the transport block is mapped to four-layer spatial multiplexing.

2. The method of claim **1**, wherein a size of each of the code blocks is equal to a size corresponding to when the size of a transport block is the 305976 bits, the 324336 bits, or the 391656 bits, and an internal interleaver size is 6144.

3. The method of claim **1**, wherein the plurality of predetermined transport block sizes further includes 314888 bits, 339112 bits, 351224 bits, 363336 bits, and 375448 bits when the transport block is mapped to four-layer spatial multiplexing, and

wherein a size of each of the code blocks is equal to a size corresponding to when the size of a transport block is the 314888 bits, the 339112 bits, the 351224 bits, the 363336 bits or the 375448 bits and an internal interleaver size is 6080.

4. The method of claim 1, wherein a turbo code internal interleaver interleaves an input bit as follow,

$$c_i'=c_{\Pi(i)}, i=0,1,\ldots,(L-1)$$

where the $c_{\Pi(i)}$ is an input bit of the interleaver, the c_i' is an output bit of the interleaver, the L is the size of the transport block, the i is an index of the input bit,

where $\Pi(i)$ is determined as below,

$$\Pi(i)=(f_1\cdot i+f_2\cdot i^2)\bmod L, \text{ and}$$

wherein the f_1 and f_2 are predetermined values according to the L, the L is the size of the transport block, the i is the index of the input bit.

5. The method of claim 1, wherein the size of the transport block is determined based on a value of a rank, the value of the rank being used by a transmitter, when the transmitter uses a multiple input multiple output (MIMO) spatial multiplexing to transmit the transport block, and

wherein the value of the rank is restricted by the modulation scheme.

6. A wireless apparatus configured for encoding a transport block in a wireless communication system, the wireless apparatus comprising:

a transceiver configured to receive radio signals; and

a processor configured to:

determine a size of the transport block,

attach a first cyclic redundancy check (CRC) code to the transport block having the determined size to produce a first CRC-attached transport block,

segment the first CRC-attached transport block into a plurality of code blocks when a size of the first CRC-attached transport block is larger than a maximum code block size,

attach a second CRC code to each of the plurality of code blocks to produce a plurality of second CRC-attached code blocks, and

encode the second CRC-attached code blocks by a turbo-encoder,

wherein the size of the transport block is determined from among a plurality of predetermined transport block sizes,

wherein the size of the transport block is determined based on a 256 quadrature amplitude modulation (QAM) scheme, a size of an allocated resource, and a number of layers, and

wherein the plurality of predetermined transport block sizes includes 305976 bits, 324336 bits, and 391656 bits when the transport block is mapped to four-layer spatial multiplexing.

7. The wireless apparatus of claim 6, wherein a size of each of the code blocks is equal to a size corresponding to when the size of a transport block is the 305976 bits, the 324336 bits, or the 391656 bits, and an internal interleaver size is 6144.

8. The wireless apparatus of claim 6, wherein the plurality of predetermined transport block sizes further includes 314888 bits, 339112 bits, 351224 bits, 363336 bits, and 375448 bits when the transport block is mapped to four-layer spatial multiplexing, and

wherein a size of each of the code blocks is equal to a size corresponding to when the size of a transport block is the 314888 bits, the 339112 bits, the 351224 bits, the 363336 bits or the 375448 bits and an internal interleaver size is 6080.

9. The wireless apparatus of claim 6, wherein a turbo code internal interleaver interleaves an input bit as follow,

$$c_i'=c_{\Pi(i)}, i=0,1,\ldots,(L-1)$$

where the $c_{\Pi(i)}$ is an input bit of the interleaver, the c_i' is an output bit of the interleaver, the L is the size of the transport block, the i is an index of the input bit,

where $\Pi(i)$ is determined as below,

$$\Pi(i)=(f_1\cdot i+f_2\cdot i^2)\bmod L, \text{ and}$$

wherein the f_1 and f_2 are predetermined values according to the L, the L is the size of the transport block, the i is the index of the input bit.

10. The wireless apparatus of claim 6, wherein the size of the transport block is determined based on a value of a rank, the value of the rank being used by a transmitter, when the transmitter uses a multiple input multiple output (MIMO) spatial multiplexing method to transmit the transport block, and

wherein the value of the rank is restricted by the modulation scheme.

* * * * *